6137 Volume 4 of 4

U.S. Army Environmental Center

FORT DEVENS
FEASIBILITY STUDY
FOR GROUP 1A SITES

FINAL
REMEDIAL INVESTIGATION ADDENDUM REPORT
DATA ITEM A009

VOLUME IV OF IV
APPENDICES I - Z

CONTRACT DAAA15-91-D-0008

U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND

DECEMBER 1993

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REMEDIAL INVESTIGATION ADDENDUM REPORT
FORT DEVENS FEASIBILITY STUDY FOR GROUP 1A SITES

APPENDICES

BACKGROUND CONCENTRATIONS AND CALCULATIONS

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CALCULATED BACKGROUND CONCENTRATIONS
FORT DEVENS, MASSACHUSETTS

SOIL		GROUNDWATER	
ANALYTE	CONCENTRATION (ug/g)	ANALYTE	CONCENTRATION (ug/L)
Aluminum	15,000	Aluminum	6,870
Antimony	--	Antimony	3.03
Arsenic	21	Arsenic	10.5
Barium	42.5	Barium	39.6
Beryllium	0.347	Beryllium	5.00
Cadmium	2.00	Cadmium	4.01
Calcium	1,400	Calcium	14,700
Chromium	31	Chromium	14.7
Cobalt	--	Cobalt	25.0
Copper	8.39	Copper	8.09
Iron	15,000	Iron	9,100
Lead	34.4	Lead	4.25
Magnesium	5,600	Magnesium	3,480
Manganese	300	Manganese	291
Mercury	0.22	Mercury	0.243
Nickel	14.0	Nickel	34.3
Potassium	1,700	Potassium	2,370
Selenium	--	Selenium	3.02
Silver	.086	Silver	4.60
Sodium	131	Sodium	10,800
Thallium	--	Thallium	6.99
Vanadium	28.7	Vanadium	11.0
Zinc	35.5	Zinc	21.1

SOIL BACKGROUND CONCENTRATIONS
REPRESENTATIVE SAMPLES
FORT DEVENS, MASSACHUSETTS

SAMPLE I.D.	LOCATION	SOIL ASSOCIATION	SAMPLE TYPE
SOIL – 1	North Post	Hinkley	Surface
SOIL – 2	North Post	Quonset	Surface
SOIL – 3	North Post	Quonset	Surface
SOIL – 4	North Post	Winooski	Surface
SOIL – 5	Main Post	Hinkley	Surface
SOIL – 6	Main Post	Hinkley	Surface
SOIL – 7	Main Post	Hinkley	Surface
SOIL –8	Main Post	Hinkley	Surface
SOIL – 9	Main Post	Paxton	Surface
SOIL – 10	Main Post	Winooski	Surface
SOIL – 11	Main Post	Winooski	Surface
SOIL – 12	Main Post	Winooski	Surface
SOIL – 13	Main Post	Paxton	Surface
SOIL – 14	South Post	Hinkley	Surface
SOIL – 15	South Post	Winooski	Surface
SOIL – 16	South Post	Paxton	Surface
SOIL – 17	Main Post	Hinkley	Boring
SOIL – 18	Main Post	Hinkley	Boring
SOIL – 19	Main Post	Hinkley	Boring
SOIL – 20	Main Post	Hinkley	Boring

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
ALUMINUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 8	2500		
SOIL – 17	4300		
SOIL – 1	6400		
SOIL – 14	6900		
SOIL – 19	7100		
SOIL – 20	7100	Minimum –	2500
SOIL – 12	7400		
SOIL – 15	8000	Maximum –	24000
SOIL – 10	8500		
SOIL – 4	8800	Mean –	10000
SOIL – 5	9900		
SOIL – 11	11000	68th %ile–	15000
SOIL – 18	11000		
SOIL – 3	12000		
SOIL – 7	12000		
SOIL – 6	13000	Background	
SOIL – 16	13000	Concentration –	15000
SOIL – 2	14000		
SOIL – 13	18000		
SOIL –9	24000		
ANTIMONY			
NO DATA AVAILABLE			
ARSENIC			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 15	4.6		
SOIL – 12	7.1		
SOIL – 3	9.3		
SOIL – 4	9.4		
SOIL – 17	9.5		
SOIL – 1	9.6	Minimum –	4.6
SOIL – 14	11		
SOIL – 19	11	Maximum –	32
SOIL – 16	11		
SOIL – 5	12	Mean –	14
SOIL – 11	13		
SOIL – 2	13	68th %ile–	21
SOIL – 10	14		
SOIL – 7	15		
SOIL – 8	15		
SOIL – 20	19	Background	
SOIL – 9	25	Concentration –	21
SOIL – 13	28		
SOIL – 6	32		
SOIL – 18	99 **		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
BARIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL - 17	9.7		
SOIL - 10	11.5		
SOIL - 6	11.5		
SOIL - 12	12.9		
SOIL - 1	14.2		
SOIL - 4	14.2	Minimum -	9.7
SOIL - 19	14.2		
SOIL - 3	14.5	Maximum -	67.2
SOIL - 5	15.5		
SOIL - 8	15.6	Mean -	25.8
SOIL - 15	16.2		
SOIL - 14	16.6	68th %ile-	42.5
SOIL - 18	29.0		
SOIL - 20	31.0		
SOIL - 2	35.0		
SOIL - 7	36.0	Background Concentration -	42.5
SOIL - 16	46.0		
SOIL - 11	52.0		
SOIL - 9	54.0		
SOIL - 13	67.2		
BERYLLIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL - 10	0.039		
SOIL - 18	0.039		
SOIL - 3	0.039		
SOIL - 17	0.039		
SOIL - 19	0.104		
SOIL - 6	0.108	Minimum -	0.039
SOIL - 1	0.119		
SOIL - 5	0.124	Maximum -	0.672
SOIL - 2	0.126		
SOIL - 7	0.133	Mean -	0.185
SOIL - 4	0.141		
SOIL - 8	0.142	68th %ile-	0.347
SOIL - 15	0.145		
SOIL - 14	0.146		
SOIL - 12	0.172		
SOIL - 20	0.188	Background Concentration -	0.347
SOIL - 9	0.335		
SOIL - 11	0.350		
SOIL - 16	0.533		
SOIL - 13	0.672		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
CADMIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL - 1	0.212		
SOIL - 20	0.212		
SOIL - 12	0.212		
SOIL - 3	0.212		
SOIL - 4	0.212		
SOIL - 5	0.212	Minimum -	0.212
SOIL - 19	0.212		
SOIL - 17	0.212	Maximum -	4.48
SOIL - 15	0.212		
SOIL - 8	0.212	Mean -	0.823
SOIL - 18	0.212		
SOIL - 16	0.212	68th %ile-	2.00
SOIL - 2	0.212		
SOIL - 14	0.212		
SOIL - 7	1.060		
SOIL - 9	1.060	Background	
SOIL - 6	1.280	Concentration -	2.00
SOIL - 10	2.100		
SOIL - 13	3.520		
SOIL - 11	4.480		
CALCIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL - 15	144		
SOIL - 8	310		
SOIL - 3	330		
SOIL - 17	350		
SOIL - 5	430		
SOIL - 2	610	Minimum -	144
SOIL - 1	610		
SOIL - 4	630	Maximum -	2800
SOIL - 18	650		
SOIL - 9	650	Mean -	840
SOIL - 6	710		
SOIL - 19	710	68th %ile-	1400
SOIL - 16	720		
SOIL - 14	740		
SOIL - 12	810		
SOIL - 20	810	Background	
SOIL - 7	1400	Concentration -	1400
SOIL - 13	1500		
SOIL - 11	1800		
SOIL - 10	2800		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
CHROMIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 15	2.0		
SOIL – 12	6.0		
SOIL – 1	7.1		
SOIL – 3	7.6		
SOIL – 17	7.7		
SOIL – 5	8.2	Minimum –	2.0
SOIL – 20	9.3		
SOIL – 8	9.6	Maximum –	56.5
SOIL – 4	10.2		
SOIL – 2	11.1	Mean –	17.7
SOIL – 1	12.5		
SOIL – 14	13.8	68th %ile–	31.3
SOIL – 19	14.1		
SOIL – 10	19.5		
SOIL – 11	27.1		
SOIL – 7	29.0	Background	
SOIL – 6	30.3	Concentration –	31
SOIL – 13	33.0		
SOIL – 18	39.5		
SOIL – 9	56.5		
COBALT			
NO DATA AVAILABLE			
COPPER			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 3	0.98		
SOIL – 16	0.98		
SOIL – 12	0.98		
SOIL – 2	2.45		
SOIL – 15	2.52		
SOIL – 8	2.53	Minimum –	0.98
SOIL – 5	4.10		
SOIL – 17	4.78	Maximum –	12.0
SOIL – 4	4.81		
SOIL – 1	5.25	Mean –	5.24
SOIL – 20	5.48		
SOIL – 6	6.55	68th %ile–	8.39
SOIL – 14	6.86		
SOIL – 19	7.12		
SOIL – 9	7.62		
SOIL – 7	9.38	Background	
SOIL – 10	10.0	Concentration –	8.39
SOIL – 18	12.0		
SOIL – 13	27.8 **		
SOIL – 11	30.2 **		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS
IRON		
SAMPLE I.D.	CONCENTRATION ug/g	
SOIL – 14	5000	
SOIL – 10	5000	
SOIL – 1	6000	
SOIL – 17	6000	
SOIL – 15	6100	
SOIL – 5	6800	Minimum – 5000
SOIL – 12	6900	
SOIL – 4	7100	Maximum – 27000
SOIL – 19	7300	
SOIL – 20	7400	Mean – 9980
SOIL – 8	8200	
SOIL – 16	8500	68th %ile– 15000
SOIL – 3	9400	
SOIL – 11	11000	
SOIL – 2	12000	
SOIL – 13	15000	Background
SOIL – 6	17000	Concentration – 15000
SOIL – 18	18000	
SOIL – 9	27000	
SOIL – 7	50000 **	
LEAD		
SAMPLE I.D.	CONCENTRATION ug/g	
SOIL – 20	2.7	
SOIL – 17	3.4	
SOIL – 5	8.7	
SOIL – 1	9.7	
SOIL – 15	10.3	
SOIL – 8	11.0	Minimum – 2.70
SOIL – 18	11.3	
SOIL – 19	12.7	Maximum – 47.1
SOIL – 9	14.8	
SOIL – 2	16.3	Mean – 20.2
SOIL – 10	17.3	
SOIL – 3	18.6	68th %ile– 34.4
SOIL – 16	21.2	
SOIL – 4	25.3	
SOIL – 6	42.8	
SOIL – 12	42.9	Background
SOIL – 7	46.6	Concentration – 34.4
SOIL – 14	47.1	
SOIL – 11	106 **	
SOIL – 13	326 **	

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
MAGNESIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 15	490		
SOIL – 3	700		
SOIL – 4	910		
SOIL – 12	1000		
SOIL – 5	1300		
SOIL – 1	1500	Minimum –	490
SOIL – 8	1800		
SOIL – 17	2000	Maximum –	11000
SOIL – 20	2200		
SOIL – 11	2300	Mean –	3100
SOIL – 2	2300		
SOIL – 10	2500	68th %ile–	5600
SOIL – 14	2600		
SOIL – 16	2700		
SOIL – 19	3200		
SOIL – 6	4500	Background Concentration –	5600
SOIL – 13	4900		
SOIL – 7	5500		
SOIL – 18	7900		
SOIL – 9	11000		
MANGANESE			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 3	73		
SOIL – 8	85		
SOIL – 5	87		
SOIL – 4	100		
SOIL – 17	110		
SOIL – 11	110	Minimum –	73
SOIL – 1	130		
SOIL – 19	130	Maximum –	460
SOIL – 14	130		
SOIL – 20	150	Mean –	190
SOIL – 12	170		
SOIL – 10	170	68th %ile–	300
SOIL – 16	190		
SOIL – 15	220		
SOIL – 6	230		
SOIL – 7	240	Background Concentration –	300
SOIL – 18	300		
SOIL – 13	350		
SOIL – 2	380		
SOIL – 9	460		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
MERCURY			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 5	0.013		
SOIL – 8	0.013		
SOIL – 20	0.013		
SOIL – 7	0.013		
SOIL – 19	0.013		
SOIL – 17	0.013	Minimum –	0.01
SOIL – 18	0.035		
SOIL – 1	0.042	Maximum –	0.41
SOIL – 16	0.053		
SOIL – 6	0.055	Mean –	0.10
SOIL – 14	0.056		
SOIL – 3	0.060	68th %ile–	0.22
SOIL – 15	0.068		
SOIL – 2	0.081		
SOIL – 9	0.085		
SOIL – 12	0.110	Background	
SOIL – 13	0.260	Concentration –	0.22
SOIL – 10	0.290		
SOIL – 4	0.330		
SOIL – 11	0.410		
NICKEL			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 16	1.23		
SOIL – 1	1.23		
SOIL – 15	1.23		
SOIL – 3	1.23		
SOIL – 8	1.23		
SOIL – 5	1.23	Minimum –	1.2
SOIL – 4	1.23		
SOIL – 2	1.23	Maximum –	27.0
SOIL – 12	1.23		
SOIL – 11	1.23	Mean –	6.5
SOIL – 14	4.06		
SOIL – 17	4.80	68th %ile–	14.0
SOIL – 20	5.51		
SOIL – 19	5.91		
SOIL – 6	6.81		
SOIL – 7	11.2	Background	
SOIL – 10	12.5	Concentration –	14.0
SOIL – 13	14.6		
SOIL – 18	24.4		
SOIL – 9	27.0		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
POTASSIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 15	250		
SOIL – 4	310		
SOIL – 5	470		
SOIL – 3	530		
SOIL – 17	590		
SOIL – 12	600	Minimum –	250
SOIL – 1	620		
SOIL – 8	630	Maximum –	2400
SOIL – 2	660		
SOIL – 14	700	Mean –	1000
SOIL – 19	880		
SOIL – 10	990	68th %ile–	1700
SOIL – 20	1000		
SOIL – 11	1100		
SOIL – 6	1100		
SOIL – 18	1700	Background	
SOIL – 7	1700	Concentration –	1700
SOIL – 13	2200		
SOIL – 9	2400		
SOIL – 16	2400		
SELENIUM			
NO DATA AVAILABLE			
SILVER			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 1	0.043		
SOIL – 20	0.043		
SOIL – 12	0.043		
SOIL – 3	0.043		
SOIL – 13	0.043		
SOIL – 5	0.043	Minimum –	0.043
SOIL – 1	0.043		
SOIL – 7	0.043	Maximum –	0.043
SOIL – 15	0.043		
SOIL – 9	0.043	Mean –	0.043
SOIL – 16	0.043		
SOIL – 2	0.043	68th %ile–	NA
SOIL – 17	0.043		
SOIL – 8	0.043		
SOIL – 19	0.043		
SOIL – 4	0.043	Background	
SOIL – 10	0.043	Concentration –	0.086 *
SOIL – 18	0.043		
SOIL – 6	0.210 **		
SOIL – 11	0.580 **		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
SODIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL - 1	26.0		
SOIL - 12	26.0		
SOIL - 15	26.0		
SOIL - 3	26.0		
SOIL - 8	26.0		
SOIL - 4	26.0	Minimum -	26.0
SOIL - 17	57.5		
SOIL - 2	58.6	Maximum -	231
SOIL - 5	71.2		
SOIL - 6	79.8	Mean -	79.7
SOIL - 9	85.8		
SOIL - 19	86.7	68th %ile-	131
SOIL - 20	93.9		
SOIL - 14	100		
SOIL - 7	117		
SOIL - 11	123	Background	
SOIL - 18	124	Concentration -	131
SOIL - 16	130		
SOIL - 13	231		
SOIL - 10	680 **		
THALLIUM			
NO DATA AVAILABLE			
VANADIUM			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL - 17	6.1		
SOIL - 15	6.2		
SOIL - 10	6.5		
SOIL - 20	7.2		
SOIL - 1	7.6		
SOIL - 5	7.9	Minimum -	6.1
SOIL - 8	8.0		
SOIL - 19	9.9	Maximum -	46.6
SOIL - 4	11.7		
SOIL - 14	13.8	Mean -	17.0
SOIL - 12	16.3		
SOIL - 2	16.6	68th %ile-	28.7
SOIL - 16	17.5		
SOIL - 3	17.9		
SOIL - 11	18.1		
SOIL - 18	22.8	Background	
SOIL - 7	23.4	Concentration -	28.7
SOIL - 6	32.3		
SOIL - 9	44.3		
SOIL - 13	46.6		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN SOIL
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
ZINC			
SAMPLE I.D.	CONCENTRATION ug/g		
SOIL – 17	11.2		
SOIL – 15	11.7		
SOIL – 8	13.2		
SOIL – 20	13.5		
SOIL – 4	13.6		
SOIL – 19	14.2	Minimum –	11.2
SOIL – 3	14.6		
SOIL – 5	14.7	Maximum –	40.0
SOIL – 1	16.5		
SOIL – 12	17.7	Mean –	23.9
SOIL – 14	22.2		
SOIL – 16	23.4	68th %ile–	35.5
SOIL – 2	27.7		
SOIL – 11	40.0		
SOIL – 18	40.0		
SOIL – 13	40.0	Background	
SOIL – 6	40.0	Concentration –	35.5
SOIL – 10	40.0		
SOIL – 7	40.0		
SOIL – 9	130.0 **		

* Method Detection Limit
** Likely Statistical Outlier

GROUNDWATER BACKGROUND CONCENTRATIONS
REPRESENTATIVE SAMPLES
FORT DEVENS, MASSACHUSETTS

MONITORING WELL	LOCATION	TOTAL SUSPENDED SOLIDS (ug/L)	ALUMINUM (ug/L)
G6M−92−09X	NORTH POST	37,000	230
G6M−92−11X	NORTH POST	53,000	1,920
WWTMW−01	NORTH POST	20,000	2,330
WWTMW−13	NORTH POST	30,000	3,150
WWTMW−14	NORTH POST	25,000	9,130
G3M−92−01X	MAIN POST	<4,000	71
13M−92−01X	MAIN POST	−	7,270
12M−92−01X	SOUTH POST	−	179
27M−92−04X	SOUTH POST	−	8,700
28M−92−01X	SOUTH POST	−	2,280

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INORGANIC ANALYTES IN WATER
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
ALUMINUM			
MONITORING WELL	CONCENTRATION (ug/L)		
G3M-92-01X	71	Minimum –	71
12M-92-01X	179	Maximum –	9140
G6M-92-09X	230		
G6M-92-11X	1920	Mean –	3527
28M-92-01X	2280		
WWTMW-01	2330	68th %ile–	6874
WWTMW-13	3150		
13M-92-01X	7270	Background Concentration –	6870
27M-92-04X	8700		
WWTMW-14	9140		
ANTIMONY			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	1.52
WWTMW-14	1.52		
WWTMW-13	1.52	Maximum –	1.52
WWTMW-01	1.52		
G6M-92-11X	1.52	Mean –	1.52
G6M-92-09X	1.52		
G3M-92-01X	1.52	68th %ile–	NA
28M-92-01X	1.52		
27M-92-04X	1.52	Background Concentration –	3.03 *
13M-92-01X	1.52		
12M-92-01X	1.52		
ARESNIC			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	1.27
G6M-92-11X	1.27		
12M-92-01X	1.27	Maximum –	15.20
G6M-92-09X	1.27		
G3M-92-01X	1.77	Mean –	5.65
28M-92-01X	3.94		
WWTMW-13	5.39	68th %ile–	10.5
WWTMW-01	9.81		
13M-92-01X	10.9	Background Concentration –	10.5
WWTMW-14	15.2		
27M-92-04X	32.3 **		
BARIUM			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	2.5
12M-92-01X	2.5		
G6M-92-09X	7.6	Maximum –	52.0
G3M-92-01X	10.7		
WWTMW-01	12.4	Mean –	22.6
28M-92-01X	14.4		
G6M-92-11X	16.1	68th %ile–	39.6
WWTMW-13	19.5		
13M-92-01X	44.5	Background Concentration –	39.6
WWTMW-14	46.3		
27M-92-04X	52.0		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN WATER
FORT DEVENS, MASSACHUSETTS

BERYLLIUM

MONITORING WELL	CONCENTRATION (ug/L)	CALCULATIONS	
G3M-92-01X	2.50	Minimum –	2.50
12M-92-01X	2.50	Maximum –	2.50
G6M-92-09X	2.50		
G6M-92-11X	2.50	Mean –	2.50
28M-92-01X	2.50		
WWTMW-01	2.50	68th %ile–	NA
WWTMW-13	2.50		
13M-92-01X	2.50	Background Concentration –	5.00 *
27M-92-04X	2.50		
WWTMW-14	2.50		

CADMIUM

MONITORING WELL	CONCENTRATION (ug/L)	CALCULATIONS	
WWTMW-14	2.01	Minimum –	2.01
WWTMW-13	2.01	Maximum –	2.01
WWTMW-01	2.01		
G6M-92-11X	2.01	Mean –	2.01
G6M-92-09X	2.01		
G3M-92-01X	2.01	68th %ile–	NA
28M-92-01X	2.01		
27M-92-04X	2.01	Background Concentration –	4.01 *
13M-92-01X	2.01		
12M-92-01X	2.01		

CALCIUM

MONITORING WELL	CONCENTRATION (ug/L)	CALCULATIONS	
12M-92-01X	179	Minimum –	179
28M-92-01X	1910	Maximum –	23200
WWTMW-14	2490		
WWTMW-13	3280	Mean –	7801
G6M-92-11X	5780		
WWTMW-01	6940	68th %ile–	14747
G3M-92-01X	7710		
27M-92-04X	8820	Background Concentration –	14700
G6M-92-09X	17700		
13M-92-01X	23200		

CHROMIUM

MONITORING WELL	CONCENTRATION (ug/L)	CALCULATIONS	
G3M-92-01X	3.01	Minimum –	3.0
G6M-92-09X	3.01	Maximum –	18.7
28M-92-01X	3.01		
12M-92-01X	3.01	Mean –	8.7
WWTMW-01	6.04		
G6M-92-11X	6.36	68th %ile–	14.7
WWTMW-13	10.1		
27M-92-04X	16.4	Background Concentration –	14.7
13M-92-01X	16.9		
WWTMW-14	18.7		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN WATER
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
COBALT			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	12.5
G3M-92-01X	12.5		
12M-92-01X	12.5	Maximum –	12.5
G6M-92-09X	12.5		
G6M-92-11X	12.5	Mean –	12.5
28M-92-01X	12.5		
WWTMW-01	12.5	68th %ile–	NA
WWTMW-13	12.5		
13M-92-01X	12.5	Background	
27M-92-04X	12.5	Concentration –	25.0 *
WWTMW-14	12.5		
COPPER			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	4.05
G3M-92-01X	4.05		
WWTMW-14	4.05	Maximum –	6.52
28M-92-01X	4.05		
WWTMW-01	4.05	Mean –	4.36
G6M-92-09X	4.05		
12M-92-01X	4.05	68th %ile–	5.2
G6M-92-11X	4.05		
WWTMW-13	6.52	Background	
13M-92-01X	18.60 **	Concentration –	8.09 *
27M-92-04X	19.00 **		
IRON			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	171
G3M-92-01X	171		
G6M-92-09X	331	Maximum –	12900
12M-92-01X	373		
G6M-92-11X	2390	Mean –	4611
28M-92-01X	2410		
WWTMW-01	3250	68th %ile–	9104
WWTMW-13	3830		
WWTMW-14	9250	Background	
27M-92-04X	11200	Concentration –	9100
13M-92-01X	12900		
LEAD			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	0.65
G6M-92-09X	0.65		
WWTMW-01	2.00	Maximum –	5.70
28M-92-01X	2.17		
G3M-92-01X	2.30	Mean –	2.81
G6M-92-11X	2.30		
WWTMW-13	3.10	68th %ile–	4.25
12M-92-01X	4.23		
WWTMW-14	5.70	Background	
13M-92-01X	12.10 **	Concentration –	4.25
27M-92-04X	12.40 **		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN WATER
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
MAGNESIUM			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	693
28M–92–01X	693		
G6M–92–11X	857	Maximum –	4500
G3M–92–01X	1000		
WWTMW–13	1390	Mean –	2157
G6M–92–09X	1600		
WWTMW–01	1900	68th %ile–	3477
WWTMW–14	1970		
27M–92–04X	3550	Background	
12M–92–01X	4110	Concentration –	3480
13M–92–01X	4500		
MANGANESE			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	23.40
G6M–92–09X	23.4		
12M–92–01X	69.9	Maximum –	486.00
WWTMW–01	77.7		
28M–92–01X	86.4	Mean –	156.93
G6M–92–11X	102		
WWTMW–13	107	68th %ile–	290.7
13M–92–01X	227		
WWTMW–14	233	Background	
G3M–92–01X	486	Concentration –	291
27M–92–04X	1110 **		
MERCURY			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	0.12
WWTMW–01	0.12		
G3M–92–01X	0.12	Maximum –	0.70
12M–92–01X	0.12		
13M–92–01X	0.12	Mean –	0.18
WWTMW–14	0.12		
28M–92–01X	0.12	68th %ile–	0.35
G6M–92–11X	0.12		
G6M–92–09X	0.12	Background	
27M–92–04X	0.12	Concentration –	0.243 *
WWTMW–13	0.70		
NICKEL			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	17.20
G6M–92–09X	17.2		
WWTMW–01	17.2	Maximum –	17.20
28M–92–01X	17.2		
G3M–92–01X	17.2	Mean –	17.20
G6M–92–11X	17.2		
WWTMW–13	17.2	68th %ile–	NA
12M–92–01X	17.2		
WWTMW–14	17.2	Background	
13M–92–01X	17.2	Concentration –	34.3 *
27M–92–04X	17.2		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN WATER
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
POTASSIUM			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	461
28M-92-01X	461		
G6M-92-11X	645	Maximum –	2790
WWTMW-13	1080		
G3M-92-01X	1450	Mean –	1644
12M-92-01X	1500		
WWTMW-01	1980	68th %ile–	2370
WWTMW-14	1980		
G6M-92-09X	1980	Background	
13M-92-01X	2570	Concentration –	2370
27M-92-04X	2790		
SELENIUM			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	1.51
G6M-92-09X	1.51		
12M-92-01X	1.51	Maximum –	1.51
WWTMW-01	1.51		
28M-92-01X	1.51	Mean –	1.51
G6M-92-11X	1.51		
WWTMW-13	1.51	68th %ile–	NA
13M-92-01X	1.51		
WWTMW-14	1.51	Background	
G3M-92-01X	1.51	Concentration –	3.02 *
27M-92-04X	1.51		
SILVER			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	2.30
WWTMW-01	2.30		
G3M-92-01X	2.30	Maximum –	2.30
12M-92-01X	2.30		
13M-92-01X	2.30	Mean –	2.30
WWTMW-14	2.30		
28M-92-01X	2.30	68th %ile–	NA
G6M-92-11X	2.30		
G6M-92-09X	2.30	Background	
27M-92-04X	2.30	Concentration –	4.60 *
WWTMW-13	2.30		
SODIUM			
MONITORING WELL	CONCENTRATION (ug/L)	Minimum –	1380
28M-92-01X	1380		
G6M-92-09X	2000	Maximum –	18000
WWTMW-14	2100		
G6M-92-11X	2430	Mean –	5771
27M-92-04X	3070		
12M-92-01X	4250	68th %ile–	10841
WWTMW-13	4610		
G3M-92-01X	8570	Background	
WWTMW-01	11300	Concentration –	10800
13M-92-01X	18000		

* Method Detection Limit
** Likely Statistical Outlier

INORGANIC ANALYTES IN WATER
FORT DEVENS, MASSACHUSETTS

DATA		CALCULATIONS	
THALLIUM			
MONITORING WELL	CONCENTRATION (ug/L)		
28M-92-01X	3.50	Minimum –	3.50
G6M-92-11X	3.50	Maximum –	3.50
WWTMW-13	3.50		
G3M-92-01X	3.50	Mean –	3.50
12M-92-01X	3.50		
WWTMW-01	3.50	68th %ile–	3.50
WWTMW-14	3.50		
G6M-92-09X	3.50	Background Concentration –	6.99
13M-92-01X	3.50		
27M-92-04X	3.50		
VANADIUM			
MONITORING WELL	CONCENTRATION (ug/L)		
G6M-92-09X	5.50	Minimum –	5.50
12M-92-01X	5.50	Maximum –	14.50
WWTMW-01	5.50		
28M-92-01X	5.50	Mean –	7.13
G6M-92-11X	5.50		
WWTMW-13	5.50	68th %ile–	10.41
13M-92-01X	5.50		
G3M-92-01X	5.50	Background Concentration –	11.0 *
27M-92-04X	12.8		
WWTMW-14	14.5		
ZINC			
MONITORING WELL	CONCENTRATION (ug/L)		
WWTMW-13	10.6	Minimum –	10.6
G6M-92-09X	10.6	Maximum –	47.0
WWTMW-01	10.6		
28M-92-01X	10.6	Mean –	20.5
G6M-92-11X	10.6		
G3M-92-01X	10.6	68th %ile–	34.9
WWTMW-14	32.0		
27M-92-04X	41.7	Background Concentration –	21.1 *
12M-92-01X	47.0		
13M-92-01X	78.5 **		

* Method Detection Limit
** Likely Statistical Outlier

RI SEDIMENT DATA SUMMARIES

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TABLE J-1
RI SEDIMENT DATA SUMMARY
SHEPLEY'S HILL LANDFILL

REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

Analysis Method Code/Analyte		SESHL01	SESHL02	SESHL03	SESHL04	SESHL05	SESHL06	SESHL07	SESHL08	SESHL09	SESHL10	SESHL11	SESHL12	SESHL13
		(Concentrations in mg/kg)												
00	Total Organic Carbon	31800	191000	117000	104000	80900	138000	231000	29500	21900	242000	218000	49100	222000
JB03	Mercury	1	27	2.1	1.7	0.55	3.5	3.5	6.07	33	53	130	72.0	38.0
JD13	Arsenic	68.0	260.0	3200	2900	1800	3200	36.0	170	200	200	380	260	290
JS15	Aluminum	14000	17000	1600	2200	14000	2700	963	23000	20000	19000	22000	9900	24000
JS15	Barium	47.4	173	210	210	160	280	10.3	210	310	176	186	76.3	202
JS15	Beryllium	0.40	1.360	<0.78	<0.78	<0.78	<0.78	<0.078	1.15	1.82	2.19	2.36	0.895	2.72
JS15	Calcium	2600	7000	12000	13000	<1300	<1300	690	6100	6400	8100	7800	2900	10000
JS15	Cadmium	<0.424	21.0	34.0	53.0	33.0	55.0	4.38	60.2	18.3	23.7	12.7	4.93	53.4
99	Lead	60.1	338	30.7	39.2	46.5	31.8	31	202	612	439	542	134	632
JS15	Chromium	270	3700	310	390	<39	<39	270	950	5400	6900	10000	4700	9300
JS15	Copper	39.7	119	<20	<20	<20	<20	6.01	54.6	132	113	122.0	60.9	128
JS15	Iron	14000	4300	280000	330000	50000	34000	4000	73000	45000	33000	33000	19000	36000
JS15	Potassium	2200	1520	185	244	996	324	90.5	2340	1740	1210.0	1310	704	1330
JS15	Magnesium	4300	3050	550	730	2600	850	164	6900	3800	2580	3090	2400	2880
JS15	Manganese	280	<84	3800	3900	<84	<84	100	8800	3400	1500	1400	310	1600
JS15	Sodium	238	<52	<520	<520	<520	<520	123	<52	799	896	588	266	825
JS15	Nickel	11.6	69.7	<25	<25	<25	<25	6.77	70.1	64.9	79.3	53.5	12.4	75.4
JS15	Vanadium	20.1	76.3	<13	<13	<13	<13	8.79	74.8	150	166	102	24.3	165
JS15	Zinc	<80	<80	<80	<80	<80	<80	42.8	<80	<80	<80	<80	<80	<80
LH13	Heptachlor	<0.012	0.020	0.092	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
LH13	4,4'-DDE	<0.04	<0.04	0.172	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
LM15	Benzo(a)anthracene	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.10	<0.3
LM15	Chrysene	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	1.50	<0.45
LM15	Fluoranthene	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	3.40	<0.52
LM15	Phenathrene	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	2.50	<0.41
LM16	Acetone	0.058	<0.01	0.29	0.15	0.54	<0.01	<0.01	0.37	0.4	0.15	0.15	<0.054	0.260
LM16	Methylene Chloride	0.023	<0.006	0.05	0.053	0.036	0.082	0.034	0.072	0.12	<0.006	0.073	0.021	0.098
LM16	Methyl Ethyl Ketone	<0.01	<0.01	0.079	<0.01	0.13	0.089	0.023	<0.01	0.13	<0.01	<0.01	<0.01	<0.01
LM15	Napthalene	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	1.60	<0.42
LM15	Pyrene	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	4.35	<0.42	3.50	2.60	<0.42

TABLE J–2
RI SEDIMENT DATA SUMMARY
COLD SPRING BROOK LANDFILL

REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

Analysis Method Code/Analyte	SECSB01	SECSB02	SECSB03	SECSB04	SECSB05	SECSB06	SECSB06 (dup)	SECSB07	SECSB08	SECSB09
					(Concentrations in mg/kg)					
00 Total Organic Carbon	52300	170000	13600	24600	10300	57600	--	51300	51900	101000
00 Total Petroleum Hydrocarbons	291	<74.4	<74.6	<74.5	<74.5	<426	--	<74.2	<74.4	2100
JD13 Arsenic	69	160	20	32	6.5	43	37	35	34	52
JS15 Lead	50.4	174	14.2	32	11.4	78.6	73	57.3	47.2	345
JS15 Aluminum	6900	12000	5500	4800	3800	17000	12000	5100	7600	17000
JS15 Barium	25.7	67.4	19.3	22.4	13.8	52.3	34.5	25.4	22.7	58.6
JS15 Beryllium	<.078	<.078	<.078	<.078	<.078	0.408	0.318	<.078	<.078	<.078
JS15 Calcium	<1300	13000	<1300	5400	1400	<1300	<1300	3600	<1300	7500
JS15 Chromium	20.1	<3.9	10.1	<3.9	7.24	38.3	31.3	<3.9	<3.9	50.7
JS15 Copper	9.16	20.4	<1.95	6.67	<1.95	19.6	14.8	<1.95	6.07	34.9
JS15 Iron	14000	45000	8500	12000	3800	20000	16000	9800	12000	31000
JS15 Mercury	0.112	0.225	<0.026	<0.026	<0.026	0.153	0.168	0.154	0.117	0.718
JS15 Potassium	565	993	348	389	308	2100	1300	430	294	3000
JS15 Magnesium	2700	3100	2100	1800	1400	5100	3800	923	1400	7000
JS15 Manganese	440	3000	500	750	130	500	500	370	370	450
JS15 Sodium	<52	<52	119	<52	76.8	216	162	<52	<52	403
JS15 Nickel	12.5	<2.46	<2.46	<2.46	<2.46	13.4	10.6	<2.46	<2.46	26.3
JS15 Vanadium	18.8	36.9	7.54	10.2	5.57	24.9	19	13.9	12.2	41.1
JS15 Zinc	<80	690	32.7	<80	14.6	<80	<80	78.3	55.6	<80
LH13 4,4'–DDD	0.297	0.625	0.034	0.102	0.083	0.72	--	<0.1	0.6	1.3
LH13 4,4'–DDE	0.08	0.202	0.017	0.042	0.047	0.14	--	<0.04	0.15	<0.04
LM15 Acenaphthalene	<0.46	<0.46	<0.46	<0.46	<0.46	<0.46	--	<0.46	<0.46	3
LM15 Anthracene	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	--	<0.54	<0.54	3
LM15 Bis(2–ethylhexy)phthalate	<0.39	<0.39	<0.39	<0.39	<0.39	<0.39	--	<0.39	<0.39	2
LM15 Benzo(a)anthracene	<0.3	<0.3	<0.3	<0.3	<0.3	0.73	--	<0.3	<0.3	4
LM15 Benzo(a)pyrene	<0.38	<0.38	<0.38	<0.38	<0.38	1.1	--	<0.38	<0.38	6
LM15 Benzo(b)fluoranthene	<0.36	<0.36	<0.36	<0.36	<0.36	0.88	--	<0.36	<0.36	5
LM15 Benzo(g,h,i)perylene	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	--	<0.24	<0.24	1
LM15 Benzo(k)fluoranthene	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	--	<0.8	<0.8	10
LM15 Chrysene	<0.45	<0.45	<0.45	<0.45	<0.45	1.1	--	<0.45	<0.45	8
LM15 Fluoranthene	<0.52	4	<0.52	<0.52	<0.52	2.1	--	<0.52	<0.52	10
LM15 Indeno(1,2,3–c,d)pyrene	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	--	<0.21	<0.21	2
LM15 Phenanthrene	<0.41	<0.41	<0.41	<0.41	<0.41	<0.41	--	<0.41	<0.41	6
LM15 Pyrene	<0.42	<0.42	<0.42	<0.42	<0.42	2.2	--	<0.42	1.2	20
LM16 Acetone	0.047	0.17	0.062	0.048	0.016	0.037	--	0.047	0.028	<0.01
LM16 Methylene Chloride	0.024	0.061	0.012	0.017	0.01	0.026	--	0.024	0.019	0.047
LM16 Methyl Ethyl Ketone	<0.01	<0.01	0.025	<0.01	<0.01	<0.01	--	<0.01	<0.01	<0.01

-- = Not analyzed

HUMAN HEALTH RISK SPREADSHEETS
SHEPLEY'S HILL LANDFILL

GSIG1UMA	15-Dec-93

TABLE K-1
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3 cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-1, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
1,2-Dichloroethane	0.0099	1	2.3E-05	0.00366	4.1E-06	0.091	0.091	2.1E-06	3.8E-07	2.5E-06
1,2-Dichloropropane	0.00052	1	1.2E-06	0.00811	4.8E-07	0.068	0.068	8.3E-08	3.3E-08	1.2E-07
Benzene	0.0017	1	4.0E-06	0.0693	1.3E-05	0.029	0.029	1.2E-07	3.9E-07	5.0E-07
Arsenic	0.39	1	9.2E-04	0.0002	8.9E-06	1.75	1.79	1.6E-03	1.6E-05	1.6E-03
Dichlorobenzenes	0.011	1	2.6E-05	0.0894	1.1E-04	0.024	0.024	6.2E-07	2.7E-06	3.3E-06
					SUMMARY CANCER RISK			2E-03	2E-05	2E-03

[1] Calculated from the Oral CSF as described in Section 6.1.2.3.

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TABLE K-1, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
1,2-Dichloropropane	0.00052	1	2.8E-06	0.00811	1.1E-06	ND	ND			
1,2-Dichloroethene (total)	0.007	1	3.8E-05	0.00888	1.7E-05	0.009	0.009	4.3E-03	1.8E-03	6.1E-03
Benzene	0.0017	1	9.3E-06	0.0693	3.1E-05	ND	ND			
Chloroethane	0.0055	1	3.0E-05	0.00513	7.5E-06	0.02	0.02	1.5E-03	3.7E-04	1.9E-03
Aluminum	75.5	1	4.1E-01	0.0002	4.0E-03	ND	ND			
Antimony	0.0033	1	1.8E-05	0.0002	1.8E-07	0.0004	0.000004	4.5E-02	4.4E-02	8.9E-02
Arsenic	0.39	1	2.1E-03	0.0002	2.1E-05	0.0003	0.000294	7.1E+00	7.1E-02	7.2E+00
Barium	0.35	1	1.9E-03	0.0002	1.9E-05	0.07	0.0049	2.7E-02	3.8E-03	3.1E-02
Calcium	219	1	1.2E+00	0.0002	1.2E-02	ND	ND			
Chromium VI	0.115	1	6.3E-04	0.0002	6.1E-06	0.005	0.00055	1.3E-01	1.1E-02	1.4E-01
Cobalt	0.0546	1	3.0E-04	0.0002	2.9E-06	ND	ND			
Copper	0.0922	1	5.1E-04	0.0002	4.9E-06	ND	ND			
Iron	97.4	1	5.3E-01	0.0002	5.2E-03	ND	ND			
Potassium	31.8	1	1.7E-01	0.0002	1.7E-03	ND	ND			
Magnesium	24	1	1.3E-01	0.0002	1.3E-03	ND	ND			
Manganese	9.65	1	5.3E-02	0.0002	5.1E-04	0.005	0.0002	1.1E+01	2.6E+00	1.3E+01
Sodium	67.3	1	3.7E-01	0.0002	3.6E-03	ND	ND			
Nickel	0.177	1	9.7E-04	0.0002	9.4E-06	0.02	0.001	4.8E-02	9.4E-03	5.8E-02
Lead	0.0668	1	3.7E-04	0.0002	3.6E-06	ND	ND			
Vanadium	0.0791	1	4.3E-04	0.0002	4.2E-06	0.007	0.00021	6.2E-02	2.0E-02	8.2E-02
Zinc	0.22	1	1.2E-03	0.0002	1.2E-05	0.3	0.102	4.0E-03	1.1E-04	4.1E-03
Dichlorobenzenes	0.011	1	6.0E-05	0.0894	2.6E-04	0.09	0.09	6.7E-04	2.9E-03	3.6E-03
1,1-Dichloroethane	0.0044	1	2.4E-05	0.00651	7.6E-06	0.1	0.1	2.4E-04	7.6E-05	3.2E-04
1,2-Dichloroethane	0.0099	1	5.4E-05	0.00366	9.6E-06	0.3	0.3	1.8E-04	3.2E-05	2.1E-04
					SUMMARY HAZARD INDEX			2E+01	3E+00	2E+01

ND = No data available
[1] Calculated from the Oral RfD as described in Section 6.1.2.3.

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TABLE K-2
INHALATION EXPOSURE TO VOCs DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION AIR	CA		ug/m^3	Modeled
CONVERSION FACTOR 1	CF1	24	hours/day	
EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b.
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
CONVERSION FACTOR 2	CF2	365	days/year	
AVERAGING TIME CANCER	AT	70	years	USEPA, 1989f
AVERAGING TIME NONCANCER	AT	30	years	USEPA, 1989f*

USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1989f. RAGs, Part A.

EQUATIONS

CANCER RISK = AVG. CONC. (ug/m^3) * CANCER UNIT RISK $(ug/m^3)^{-1}$

HAZARD QUOTIENT = AVG.CONC.(ug/m^3)/REF. CONC. (ug/m^3)

$$\text{AVG. CONC.} = \frac{CAair * EF * ET * ED}{AT * CF1 * CF2}$$

Note:
*For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. LIFETIME (ug/m^3)	INHALATION UNIT RISK $(ug/m^3)^{-1}$	CANCER RISK
1,2-Dichloroethane	4.1E+01	1.4E-01	2.6E-05	3.7E-06
Benzene	9.1E+00	3.1E-02	8.3E-06	2.6E-07
		SUMMARY CANCER RISK		4E-06

NONCARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. FOR TIME PERIOD (ug/m^3)	INHALATION RfC (ug/m^3)	HAZARD QUOTIENT
Benzene	9.1E+00	7.3E-02	2.0E-01	3.6E-01
Chloroethane	3.2E+01	2.6E-01	1.0E+04	2.6E-05
1,1-Dichloroethane	2.1E+01	1.7E-01	5.0E+02	3.4E-04
1,2-Dichloroethane	4.1E+01	3.3E-01	1.0E+01	3.3E-02
1,2-Dichloropropane	2.3E+00	1.8E-02	4.0E+00	4.5E-03
1,2-Dichloroethene (total)	3.5E+01	2.8E-01	ND	
		SUMMARY HAZARD INDEX		0.401

ND = No data available

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TABLE K-3
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 19989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-3, continued
GROUNDWATER - INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE - (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL - WELL GROUP 1
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FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
1,2-Dichloroethane	0.0099	1	4.2E-06	0.00366	1.1E-06	0.091	0.091	3.9E-07	1.0E-07	4.9E-07
1,2-Dichloropropane	0.00052	1	2.2E-07	0.00811	1.3E-07	0.068	0.068	1.5E-08	8.8E-09	2.4E-08
Benzene	0.0017	1	7.3E-07	0.0693	3.6E-06	0.029	0.029	2.1E-08	1.1E-07	1.3E-07
Arsenic	0.39	1	1.7E-04	0.0002	2.4E-06	1.75	1.79	2.9E-04	4.3E-06	3.0E-04
Dichlorobenzenes	0.011	1	4.7E-06	0.0894	3.0E-05	0.024	0.024	1.1E-07	7.3E-07	8.4E-07
					SUMMARY CANCER RISK			3E-04	5E-06	3E-04

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

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TABLE K-3, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
1,2-Dichloropropane	0.00052	1	3.1E-06	0.00811	1.8E-06	ND	ND			
1,2-Dichloroethene (total)	0.007	1	4.2E-05	0.00888	2.7E-05	0.009	0.009	4.7E-03	3.0E-03	7.6E-03
Benzene	0.0017	1	1.0E-05	0.0693	5.1E-05	ND	ND			
Chloroethane	0.0055	1	3.3E-05	0.00513	1.2E-05	0.02	0.02	1.6E-03	6.1E-04	2.3E-03
Aluminum	75.5	1	4.5E-01	0.0002	6.5E-03	ND	ND			
Antimony	0.0033	1	2.0E-05	0.0002	2.8E-07	0.0004	0.000004	4.9E-02	7.1E-02	1.2E-01
Arsenic	0.39	1	2.3E-03	0.0002	3.4E-05	0.0003	0.000294	7.8E+00	1.1E-01	7.9E+00
Barium	0.35	1	2.1E-03	0.0002	3.0E-05	0.07	0.0049	3.0E-02	6.2E-03	3.6E-02
Calcium	219	1	1.3E+00	0.0002	1.9E-02	ND	ND			
Chromium VI	0.115	1	6.9E-04	0.0002	9.9E-06	0.02	0.0022	3.4E-02	4.5E-03	3.9E-02
Cobalt	0.0546	1	3.3E-04	0.0002	4.7E-06	ND	ND			
Copper	0.0922	1	5.5E-04	0.0002	7.9E-06	ND	ND			
Iron	97.4	1	5.8E-01	0.0002	8.4E-03	ND	ND			
Potassium	31.8	1	1.9E-01	0.0002	2.7E-03	ND	ND			
Magnesium	24	1	1.4E-01	0.0002	2.1E-03	ND	ND			
Manganese	9.65	1	5.8E-02	0.0002	8.3E-04	0.005	0.0002	1.2E+01	4.2E+00	1.6E+01
Sodium	67.3	1	4.0E-01	0.0002	5.8E-03	ND	ND			
Nickel	0.177	1	1.1E-03	0.0002	1.5E-05	0.02	0.001	5.3E-02	1.5E-02	6.8E-02
Lead	0.0668	1	4.0E-04	0.0002	5.8E-06	ND	ND			
Vanadium	0.0791	1	4.7E-04	0.0002	6.8E-06	0.007	0.00021	6.8E-02	3.2E-02	1.0E-01
Zinc	0.22	1	1.3E-03	0.0002	1.9E-05	0.3	0.102	4.4E-03	1.9E-04	4.6E-03
Dichlorobenzenes	0.011	1	6.6E-05	0.0894	4.2E-04	0.9	0.9	7.3E-05	4.7E-04	5.4E-04
1,1-Dichloroethane	0.0044	1	2.6E-05	0.00651	1.2E-05	1	1	2.6E-05	1.2E-05	3.9E-05
1,2-Dichloroethane	0.0099	1	5.9E-05	0.00366	1.6E-05	0.3	0.3	2.0E-04	5.2E-05	2.5E-04
					SUMMARY HAZARD INDEX			**2E+01**	**4E+00**	**2E+01**

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-4
INHALATION EXPOSURE TO VOCs DURING SHOWERING
CHILD EXPOSURE (SUBCHRONIC) – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION AIR	CA		ug/m^3	Modeled
CONVERSION FACTOR 1	CF1	24	hours/day	
EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	USEPA, 1991b
CONVERSION FACTOR 2	CF2	365	days/year	
AVERAGING TIME CANCER	AT	70	years	USEPA, 1989f
AVERAGING TIME NONCANCER	AT	5	years	USEPA, 1989f*

USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1989f. RAGs, Part A.

EQUATIONS

CANCER RISK = AVG. CONC. (ug/m^3) * CANCER UNIT RISK $(ug/m3)^{-1}$

HAZARD QUOTIENT = AVG.CONC.(ug/m^3)/REF. CONC. (ug/m^3)

$$\text{AVG. CONC.} = \frac{CAair * EF * ET * ED}{AT * CF1 * CF2}$$

Note:
*For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. LIFETIME (ug/m^3)	INHALATION UNIT RISK $(ug/m^3)^{-1}$	CANCER RISK
1,2-Dichloroethane	4.1E+01	2.3E-02	2.6E-05	6.1E-07
Benzene	9.1E+00	5.2E-03	8.3E-06	4.3E-08
		SUMMARY CANCER RISK		7E-07

NONCARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. FOR TIME PERIOD (ug/m^3)	INHALATION RfC (ug/m^3)	HAZARD QUOTIENT
Benzene	9.1E+00	7.3E-02	2.0E-01	3.6E-01
Chloroethane	3.2E+01	2.6E-01	1.0E+04	2.6E-05
1,1-Dichloroethane	2.1E+01	1.7E-01	5.0E+03	3.4E-05
1,2-Dichloroethane	4.1E+01	3.3E-01	1.0E+01	3.3E-02
1,2-Dichloropropane	2.3E+00	1.8E-02	1.3E+01	1.4E-03
1,2-Dichloroethene (total)	3.5E+01	2.8E-01	ND	
		SUMMARY HAZARD INDEX		0.398

ND = No data available

TABLE K-5
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-5, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
1,2-Dichloroethane	0.00097	1	2.3E-06	0.00366	4.0E-07	0.091	0.091	2.1E-07	3.7E-08	2.4E-07
1,2-Dichloropropane	0.00027	1	6.3E-07	0.00811	2.5E-07	0.068	0.068	4.3E-08	1.7E-08	6.0E-08
Benzene	0.00051	1	1.2E-06	0.0693	4.0E-06	0.029	0.029	3.5E-08	1.2E-07	1.5E-07
Arsenic	0.101	1	2.4E-04	0.0002	2.3E-06	1.75	1.79	4.2E-04	4.1E-06	4.2E-04
Dichlorobenzenes	0.0054	1	1.3E-05	0.0894	5.5E-05	0.024	0.024	3.0E-07	1.3E-06	1.6E-06
					SUMMARY CANCER RISK			4E-04	6E-06	4E-04

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE K-5, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
1,2-Dichloropropane	0.00027	1	1.5E-06	0.00811	5.8E-07	ND	ND			
1,2-Dichloroethene (total)	0.0014	1	7.7E-06	0.00888	3.3E-06	0.009	0.009	8.5E-04	3.7E-04	1.2E-03
Benzene	0.00051	1	2.8E-06	0.0693	9.4E-06	ND	ND			
Chloroethane	0.0013	1	7.1E-06	0.00513	1.8E-06	0.02	0.02	3.6E-04	8.9E-05	4.4E-04
Aluminum	4.26	1	2.3E-02	0.0002	2.3E-04	ND	ND			
Antimony	0.0017	1	9.3E-06	0.0002	9.0E-08	0.0004	0.000004	2.3E-02	2.3E-02	4.6E-02
Arsenic	0.101	1	5.5E-04	0.0002	5.4E-06	0.0003	0.000294	1.8E+00	1.8E-02	1.9E+00
Barium	0.0476	1	2.6E-04	0.0002	2.5E-06	0.07	0.0049	3.7E-03	5.2E-04	4.2E-03
Calcium	54.3	1	3.0E-01	0.0002	2.9E-03	ND	ND			
Chromium VI	0.009	1	4.9E-05	0.0002	4.8E-07	0.005	0.00055	9.9E-03	8.7E-04	1.1E-02
Cobalt	0.014	1	7.7E-05	0.0002	7.4E-07	ND	ND			
Copper	0.0086	1	4.7E-05	0.0002	4.6E-07	ND	ND			
Iron	17.6	1	9.6E-02	0.0002	9.4E-04	ND	ND			
Potassium	7.12	1	3.9E-02	0.0002	3.8E-04	ND	ND			
Magnesium	7.6	1	4.2E-02	0.0002	4.0E-04	ND	ND			
Manganese	2.05	1	1.1E-02	0.0002	1.1E-04	0.005	0.0002	2.2E+00	5.4E-01	2.8E+00
Sodium	20.7	1	1.1E-01	0.0002	1.1E-03	ND	ND			
Nickel	0.0229	1	1.3E-04	0.0002	1.2E-06	0.02	0.001	6.3E-03	1.2E-03	7.5E-03
Lead	0.0052	1	2.8E-05	0.0002	2.8E-07	ND	ND			
Vanadium	0.0094	1	5.2E-05	0.0002	5.0E-07	0.007	0.00021	7.4E-03	2.4E-03	9.7E-03
Zinc	0.0294	1	1.6E-04	0.0002	1.6E-06	0.3	0.102	5.4E-04	1.5E-05	5.5E-04
Dichlorobenzenes	0.0054	1	3.0E-05	0.0894	1.3E-04	0.09	0.09	3.3E-04	1.4E-03	1.8E-03
1,1-Dichloroethane	0.00086	1	4.7E-06	0.00651	1.5E-06	0.1	0.1	4.7E-05	1.5E-05	6.2E-05
1,2-Dichloroethane	0.00097	1	5.3E-06	0.00366	9.4E-07	0.3	0.3	1.8E-05	3.1E-06	2.1E-05
					SUMMARY HAZARD INDEX			**4E+00**	**6E-01**	**5E+00**

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-6
INHALATION EXPOSURE TO VOCs DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION AIR	CA		ug/m^3	Modeled
CONVERSION FACTOR 1	CF1	24	hours/day	
EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
CONVERSION FACTOR 2	CF2	365	days/year	
AVERAGING TIME CANCER	AT	70	years	USEPA, 1989f
AVERAGING TIME NONCANCER	AT	30	years	USEPA, 1989f*

USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1989f. RAGs, Part A.

EQUATIONS

CANCER RISK = AVG. CONC. (ug/m^3) * CANCER UNIT RISK (ug/m^3)$^{-1}$

HAZARD QUOTIENT = AVG.CONC.(ug/m^3)/REF. CONC. (ug/m^3)

$$\text{AVG. CONC.} = \frac{\text{CAair} * \text{EF} * \text{ET} * \text{ED}}{\text{AT} * \text{CF1} * \text{CF2}}$$

Note:
*For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVG. CONC. LIFETIME (ug/m^3)	INHALATION UNIT RISK (ug/m3)$^{-1}$	CANCER RISK
1,2-Dichloroethane	4.0E+00	1.4E-02	2.6E-05	3.6E-07
Benzene	2.7E+00	9.2E-03	8.3E-06	7.7E-08
		SUMMARY CANCER RISK		4E-07

NONCARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVG. CONC. FOR TIME PERIOD (ug/m^3)	INHALATION RfC (ug/m^3)	HAZARD QUOTIENT
Benzene	2.7E+00	2.2E-02	2.0E-01	1.1E-01
Chloroethane	7.7E+00	6.1E-02	1.0E+04	6.1E-06
1,1-Dichloroethane	4.1E+00	3.3E-02	5.0E+02	6.6E-05
1,2-Dichloroethane	4.0E+00	3.2E-02	1.0E+01	3.2E-03
1,2-Dichloropropane	1.2E+00	9.3E-03	4.0E+00	2.3E-03
1,2-Dichloroethene (total)	6.9E+00	5.5E-02	ND	
		SUMMARY HAZARD INDEX		0.113

ND = *No data available*

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TABLE K-7
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/10^3cm^3	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 19989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365 \text{ days/yr}}$$

Where:

$$DA_{event} = PC_{event} \times CW$$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-7, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
1,2-Dichloroethane	0.00097	1	4.2E-07	0.00366	1.1E-07	0.091	0.091	3.8E-08	9.9E-09	4.8E-08
1,2-Dichloropropane	0.00027	1	1.2E-07	0.00811	6.7E-08	0.068	0.068	7.9E-09	4.6E-09	1.2E-08
Benzene	0.00051	1	2.2E-07	0.0693	1.1E-06	0.029	0.029	6.3E-09	3.2E-08	3.8E-08
Arsenic	0.101	1	4.3E-05	0.0002	6.2E-07	1.75	1.79	7.6E-05	1.1E-06	7.7E-05
Dichlorobenzenes	0.0054	1	2.3E-06	0.0894	1.5E-05	0.024	0.024	5.5E-08	3.6E-07	4.1E-07
					SUMMARY CANCER RISK			8E-05	2E-06	8E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE K-7, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
1,2-Dichloropropane	0.00027	1	1.6E-06	0.00811	9.4E-07	ND	ND			
1,2-Dichloroethene (total)	0.0014	1	8.4E-06	0.00888	5.4E-06	0.009	0.009	9.3E-04	6.0E-04	1.5E-03
Benzene	0.00051	1	3.1E-06	0.0693	1.5E-05	ND	ND			
Chloroethane	0.0013	1	7.8E-06	0.00513	2.9E-06	0.02	0.02	3.9E-04	1.4E-04	5.3E-04
Aluminum	4.26	1	2.6E-02	0.0002	3.7E-04	ND	ND			
Antimony	0.0017	1	1.0E-05	0.0002	1.5E-07	0.0004	0.000004	2.5E-02	3.7E-02	6.2E-02
Arsenic	0.101	1	6.1E-04	0.0002	8.7E-06	0.0003	0.000294	2.0E+00	3.0E-02	2.0E+00
Barium	0.0476	1	2.9E-04	0.0002	4.1E-06	0.07	0.0049	4.1E-03	8.4E-04	4.9E-03
Calcium	54.3	1	3.3E-01	0.0002	4.7E-03	ND	ND			
Chromium VI	0.009	1	5.4E-05	0.0002	7.8E-07	0.02	0.0022	2.7E-03	3.5E-04	3.0E-03
Cobalt	0.014	1	8.4E-05	0.0002	1.2E-06	ND	ND			
Copper	0.0086	1	5.2E-05	0.0002	7.4E-07	ND	ND			
Iron	17.6	1	1.1E-01	0.0002	1.5E-03	ND	ND			
Potassium	7.12	1	4.3E-02	0.0002	6.1E-04	ND	ND			
Magnesium	7.6	1	4.6E-02	0.0002	6.6E-04	ND	ND			
Manganese	2.05	1	1.2E-02	0.0002	1.8E-04	0.005	0.0002	2.5E+00	8.8E-01	3.3E+00
Sodium	20.7	1	1.2E-01	0.0002	1.8E-03	ND	ND			
Nickel	0.0229	1	1.4E-04	0.0002	2.0E-06	0.02	0.001	6.9E-03	2.0E-03	8.8E-03
Lead	0.0052	1	3.1E-05	0.0002	4.5E-07	ND	ND			
Vanadium	0.0094	1	5.6E-05	0.0002	8.1E-07	0.007	0.00021	8.0E-03	3.9E-03	1.2E-02
Zinc	0.0294	1	1.8E-04	0.0002	2.5E-06	0.3	0.102	5.9E-04	2.5E-05	6.1E-04
Dichlorobenzenes	0.0054	1	3.2E-05	0.0894	2.1E-04	0.9	0.9	3.6E-05	2.3E-04	2.7E-04
1,1-Dichloroethane	0.00086	1	5.2E-06	0.00651	2.4E-06	1	1	5.2E-06	2.4E-06	7.6E-06
1,2-Dichloroethane	0.00097	1	5.8E-06	0.00366	1.5E-06	0.3	0.3	1.9E-05	5.1E-06	2.4E-05
					SUMMARY HAZARD INDEX			5E+00	1E+00	5E+00

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-8
INHALATION EXPOSURE TO VOCs DURING SHOWERING
CHILD EXPOSURE (SUBCHRONIC) – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION AIR	CA		ug/m^3	Modeled
CONVERSION FACTOR 1	CF1	24	hours/day	
EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	USEPA, 1991b
CONVERSION FACTOR 2	CF2	365	days/year	
AVERAGING TIME CANCER	AT	70	years	USEPA, 1989f
AVERAGING TIME NONCANCER	AT	5	years	USEPA, 1989f*

USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1989f. RAGs, Part A.

EQUATIONS

CANCER RISK = AVG. CONC. (ug/m^3) * CANCER UNIT RISK $(ug/m^3)^{-1}$

HAZARD QUOTIENT = AVG.CONC.(ug/m^3)/REF. CONC. (ug/m^3)

$$\text{AVG. CONC.} = \frac{CAair * EF * ET * ED}{AT * CF1 * CF2}$$

Note:
*For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVG. CONC. LIFETIME (ug/m^3)	INHALATION UNIT RISK $(ug/m^3)^{-1}$	CANCER RISK
1,2-Dichloroethane	4.0E+00	2.3E-03	2.6E-05	5.9E-08
Benzene	2.7E+00	1.5E-03	8.3E-06	1.3E-08
			SUMMARY CANCER RISK	7E-08

NONCARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVG. CONC. FOR TIME PERIOD (ug/m^3)	INHALATION RfC (ug/m^3)	HAZARD QUOTIENT
Benzene	2.7E+00	2.2E-02	2.0E-01	1.1E-01
Chloroethane	7.7E+00	6.1E-02	1.0E+04	6.1E-06
1,1-Dichloroethane	4.1E+00	3.3E-02	5.0E+03	6.6E-06
1,2-Dichloroethane	4.0E+00	3.2E-02	1.0E+01	3.2E-03
1,2-Dichloropropane	1.2E+00	9.3E-03	1.3E+01	7.2E-04
1,2-Dichloroethene	6.9E+00	5.5E-02	ND	
			SUMMARY HAZARD INDEX	0.112

ND = No data available

TABLE K-9
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2–event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg–day) x CANCER SLOPE FACTOR (mg/kg–day)^–1

HAZARD QUOTIENT = INTAKE (mg/kg–day) / REFERENCE DOSE (mg/kg–day)

$$\text{INTAKE–INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE–DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:

$$DA_{event} = PC_{event} \times CW$$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-9, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
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COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.27	1	6.3E-04	0.0002	6.2E-06	1.75	1.79	1.1E-03	1.1E-05	1.1E-03
					SUMMARY CANCER RISK			**1E-03**	**1E-05**	**1E-03**

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

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TABLE K-9, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Antimony	0.00312	1	1.7E-05	0.0002	1.7E-07	0.0004	0.000004	4.3E-02	4.1E-02	8.4E-02
Arsenic	0.27	1	1.5E-03	0.0002	1.4E-05	0.0003	0.000294	4.9E+00	4.9E-02	5.0E+00
Barium	0.117	1	6.4E-04	0.0002	6.2E-06	0.07	0.0049	9.2E-03	1.3E-03	1.0E-02
Calcium	175	1	9.6E-01	0.0002	9.3E-03	ND	ND			
Iron	91.6	1	5.0E-01	0.0002	4.9E-03	ND	ND			
Potassium	10.6	1	5.8E-02	0.0002	5.6E-04	ND	ND			
Magnesium	19.9	1	1.1E-01	0.0002	1.1E-03	ND	ND			
Manganese	9.54	1	5.2E-02	0.0002	5.1E-04	0.005	0.0002	1.0E+01	2.5E+00	1.3E+01
Sodium	64.6	1	3.5E-01	0.0002	3.4E-03	ND	ND			
Zinc	0.0255	1	1.4E-04	0.0002	1.4E-06	0.3	0.102	4.7E-04	1.3E-05	4.8E-04
					SUMMARY HAZARD INDEX			2E+01	3E+00	2E+01

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-10
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 19989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-10, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	DERMAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.27	1	1.2E-04	0.0002	1.7E-06	1.75	1.79	2.0E-04	3.0E-06	2.1E-04
					SUMMARY CANCER RISK			2E-04	3E-06	2E-04

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE K-10, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD [1] (mg/kg-day)	DERMAL RfD (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Antimony	0.00312	1	1.9E-05	0.0002	2.7E-07	0.0004	0.000004	4.7E-02	6.7E-02	1.1E-01
Arsenic	0.27	1	1.6E-03	0.0002	2.3E-05	0.0003	0.000294	5.4E+00	7.9E-02	5.5E+00
Barium	0.117	1	7.0E-04	0.0002	1.0E-05	0.07	0.0049	1.0E-02	2.1E-03	1.2E-02
Calcium	175	1	1.0E+00	0.0002	1.5E-02	ND	ND			
Iron	91.6	1	5.5E-01	0.0002	7.9E-03	ND	ND			
Potassium	10.6	1	6.4E-02	0.0002	9.1E-04	ND	ND			
Magnesium	19.9	1	1.2E-01	0.0002	1.7E-03	ND	ND			
Manganese	9.54	1	5.7E-02	0.0002	8.2E-04	0.005	0.0002	1.1E+01	4.1E+00	1.6E+01
Sodium	64.6	1	3.9E-01	0.0002	5.6E-03	ND	ND			
Zinc	0.0255	1	1.5E-04	0.0002	2.2E-06	0.3	0.102	5.1E-04	2.2E-05	5.3E-04
SUMMARY HAZARD INDEX								2E+01	4E+00	2E+01

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-11
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-11, continued
GROUNDWATER - INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE - FILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL - WELL GROUP 1
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	DERMAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.071	1	1.7E-04	0.0002	1.6E-06	1.75	1.79	2.9E-04	2.9E-06	2.9E-04
					SUMMARY CANCER RISK			3E-04	3E-06	3E-04

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE K-11, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD [1] (mg/kg-day)	DERMAL RfD (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Antimony	0.002	1	1.1E-05	0.0002	1.1E-07	0.0004	0.000004	2.7E-02	2.7E-02	5.4E-02
Arsenic	0.071	1	3.9E-04	0.0002	3.8E-06	0.0003	0.000294	1.3E+00	1.3E-02	1.3E+00
Barium	0.03	1	1.6E-04	0.0002	1.6E-06	0.07	0.0049	2.3E-03	3.3E-04	2.7E-03
Calcium	37.4	1	2.0E-01	0.0002	2.0E-03	ND	ND			
Iron	14.4	1	7.9E-02	0.0002	7.7E-04	ND	ND			
Potassium	4.13	1	2.3E-02	0.0002	2.2E-04	ND	ND			
Magnesium	4.68	1	2.6E-02	0.0002	2.5E-04	ND	ND			
Manganese	1.81	1	9.9E-03	0.0002	9.6E-05	0.005	0.0002	2.0E+00	4.8E-01	2.5E+00
Sodium	16.9	1	9.3E-02	0.0002	9.0E-04	ND	ND			
Zinc	0.011	1	6.0E-05	0.0002	5.8E-07	0.3	0.102	2.0E-04	5.7E-06	2.1E-04
					SUMMARY HAZARD INDEX			3E+00	5E-01	4E+00

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-12
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 19989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-12, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.071	1	3.0E-05	0.0002	4.4E-07	1.75	1.79	5.3E-05	7.8E-07	5.4E-05
SUMMARY CANCER RISK								5E-05	8E-07	5E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

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TABLE K-12, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Antimony	0.002	1	1.2E-05	0.0002	1.7E-07	0.0004	0.000004	3.0E-02	4.3E-02	7.3E-02
Arsenic	0.071	1	4.3E-04	0.0002	6.1E-06	0.0003	0.000294	1.4E+00	2.1E-02	1.4E+00
Barium	0.03	1	1.8E-04	0.0002	2.6E-06	0.07	0.0049	2.6E-03	5.3E-04	3.1E-03
Calcium	37.4	1	2.2E-01	0.0002	3.2E-03	ND	ND			
Iron	14.4	1	8.6E-02	0.0002	1.2E-03	ND	ND			
Potassium	4.13	1	2.5E-02	0.0002	3.6E-04	ND	ND			
Magnesium	4.68	1	2.8E-02	0.0002	4.0E-04	ND	ND			
Manganese	1.81	1	1.1E-02	0.0002	1.6E-04	0.005	0.0002	2.2E+00	7.8E-01	2.9E+00
Sodium	16.9	1	1.0E-01	0.0002	1.5E-03	ND	ND			
Zinc	0.011	1	6.6E-05	0.0002	9.5E-07	0.3	0.102	2.2E-04	9.3E-06	2.3E-04
					SUMMARY HAZARD INDEX			**4E+00**	**8E-01**	**4E+00**

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-13
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-13, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.017	1	4.0E-05	0.0002	3.9E-07	1.75	1.79	7.0E-05	6.9E-07	7.1E-05
					SUMMARY CANCER RISK			7E-05	7E-07	7E-05

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.017	1	9.3E-05	0.0002	9.0E-07	0.0003	0.000294	3.1E-01	3.1E-03	3.1E-01
Calcium	15.4	1	8.4E-02	0.0002	8.2E-04	ND	ND			
Manganese	1.59	1	8.7E-03	0.0002	8.5E-05	0.005	0.0002	1.7E+00	4.2E-01	2.2E+00
Sodium	17.3	1	9.5E-02	0.0002	9.2E-04	ND	ND			
Lead	0.00738	1	4.0E-05	0.0002	3.9E-07	ND	ND			
					SUMMARY HAZARD INDEX			2E+00	4E-01	2E+00

ND = No data available
[1] Calculated from Oral CSF as described in Section 6.1.2.3.
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-14
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-14, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.017	1	7.3E-06	0.0002	1.0E-07	1.75	1.79	1.3E-05	1.9E-07	1.3E-05
					SUMMARY CANCER RISK			1E-05	2E-07	1E-05

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.017	1	1.0E-04	0.0002	1.5E-06	0.0003	0.000294	3.4E-01	5.0E-03	3.4E-01
Calcium	15.4	1	9.2E-02	0.0002	1.3E-03	ND	ND			
Manganese	1.59	1	9.5E-03	0.0002	1.4E-04	0.005	0.0002	1.9E+00	6.9E-01	2.6E+00
Sodium	17.3	1	1.0E-01	0.0002	1.5E-03	ND	ND			
Lead	0.00738	1	4.4E-05	0.0002	6.4E-07	ND	ND			
					SUMMARY HAZARD INDEX			2E+00	7E-01	3E+00

ND = No data available
[1] Calculated from Oral CSF as described in Section 6.1.2.3.
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-15
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
FORT DEVENS, MA

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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3 cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-15, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0084	1	2.0E-05	0.0002	1.9E-07	1.75	1.79	3.5E-05	3.4E-07	3.5E-05
					SUMMARY CANCER RISK			**3E-05**	**3E-07**	**3E-05**

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.0084	1	4.6E-05	0.0002	4.5E-07	0.0003	0.000294	1.5E-01	1.5E-03	1.5E-01
Calcium	1.1	1	6.0E-03	0.0002	5.8E-05	ND	ND			
Manganese	0.68	1	3.7E-03	0.0002	3.6E-05	0.005	0.0002	7.5E-01	1.8E-01	9.3E-01
Sodium	7.6	1	4.2E-02	0.0002	4.0E-04	ND	ND			
Lead	0.0034	1	1.9E-05	0.0002	1.8E-07	ND	ND			
					SUMMARY HAZARD INDEX			**9E-01**	**2E-01**	**1E+00**

ND = No data available
[1] Calculated from Oral CSF as described in Section 6.1.2.3.
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-16
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-16, continued
GROUNDWATER - INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE - (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
SHEPLEY'S HILL LANDFILL - WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	DERMAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0084	1	3.6E-06	0.0002	5.2E-08	1.75	1.79	6.3E-06	9.3E-08	6.4E-06
					SUMMARY CANCER RISK			6E-06	9E-08	6E-06

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD [2] (mg/kg-day)	DERMAL RfD (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.0084	1	5.0E-05	0.0002	7.2E-07	0.0003	0.000294	1.7E-01	2.5E-03	1.7E-01
Calcium	1.1	1	6.6E-03	0.0002	9.5E-05	ND	ND			
Manganese	0.68	1	4.1E-03	0.0002	5.9E-05	0.005	0.0002	8.2E-01	2.9E-01	1.1E+00
Sodium	7.6	1	4.6E-02	0.0002	6.6E-04	ND	ND			
Lead	0.0034	1	2.0E-05	0.0002	2.9E-07	ND	ND			
					SUMMARY HAZARD INDEX			1E+00	3E-01	1E+00

ND = No data available
[1] Calculated from Oral CSF as described in Section 6.1.2.3.
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-17
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:

$$DA_{event} = PC_{event} \times CW$$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-17, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
No carcinogenic compounds detected										
					SUMMARY CANCER RISK			0E+00	0E+00	0E+00

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Sodium	16.4	1	9.0E-02	0.0002	8.7E-04	ND	ND			
					SUMMARY HAZARD INDEX			0E+00	0E+00	0E+00

ND = No data available
[1] Calculated from Oral CSF as described in Section 6.1.2.3.
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-18
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/10^3cm^3	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-18, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 3
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
No carcinogenic compounds detected										
					SUMMARY CANCER RISK			0E+00	0E+00	0E+00

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Sodium	16.4	1	9.8E-02	0.0002	1.4E-03	ND	ND			
					SUMMARY HAZARD INDEX			0E+00	0E+00	0E+00

ND = No data available
[1] Calculated from Oral CSF as described in Section 6.1.2.3.
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-19
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2–event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/10^3cm^3	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg–day) x CANCER SLOPE FACTOR (mg/kg–day)^–1

HAZARD QUOTIENT = INTAKE (mg/kg–day) / REFERENCE DOSE (mg/kg–day)

$$\text{INTAKE–INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE–DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-19, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
FORT DEVENS, MA

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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.024	1	5.6E-05	0.0002	5.5E-07	1.75	1.79	9.9E-05	9.8E-07	1.0E-04
					SUMMARY CANCER RISK			**1E-04**	**1E-06**	**1E-04**

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

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TABLE K-19, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.024	1	1.3E-04	0.0002	1.3E-06	0.0003	0.000294	4.4E-01	4.3E-03	4.4E-01
Calcium	15.6	1	8.5E-02	0.0002	8.3E-04	ND	ND			
Potassium	3.26	1	1.8E-02	0.0002	1.7E-04	ND	ND			
Manganese	1.43	1	7.8E-03	0.0002	7.6E-05	0.005	0.0002	1.6E+00	3.8E-01	1.9E+00
Zinc	0.0358	1	2.0E-04	0.0002	1.9E-06	0.3	0.102	6.5E-04	1.9E-05	6.7E-04
Trichlorofluoromethane	0.0021	1	1.2E-05	0.0163	9.1E-06	0.3	0.3	3.8E-05	3.0E-05	6.9E-05
					SUMMARY HAZARD INDEX			2E+00	4E-01	2E+00

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-20
INHALATION EXPOSURE TO VOCs DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION AIR	CA		ug/m^3	Modeled
CONVERSION FACTOR 1	CF1	24	hours/day	
EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
CONVERSION FACTOR 2	CF2	365	days/year	
AVERAGING TIME CANCER	AT	70	years	USEPA, 1989f
AVERAGING TIME NONCANCER	AT	30	years	USEPA, 1989f*

USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1989f. RAGs, Part A.

EQUATIONS

CANCER RISK = AVG. CONC. (ug/m^3) * CANCER UNIT RISK $(ug/m^3)^{-1}$

HAZARD QUOTIENT = AVG.CONC.(ug/m^3)/REF. CONC. (ug/m^3)

$$\text{AVG. CONC.} = \frac{CAair * EF * ET * ED}{AT * CF1 * CF2}$$

Note:
*For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. LIFETIME (ug/m^3)	INHALATION UNIT RISK $(ug/m^3)^{-1}$	CANCER RISK
No carcinogenic VOCs detected				
			SUMMARY CANCER RISK	0E+00

NONCARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. FOR TIME PERIOD (ug/m^3)	INHALATION RfC (ug/m^3)	HAZARD QUOTIENT
Trichlorofluoromethane	9.2E+00	7.4E-02	7.0E+02	1.1E-04
			SUMMARY HAZARD INDEX	0.0001

ND = No data available

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TABLE K-21
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3 cm^3$	

[1] In estimating the dermally absorbed dose for children age 1 to 6, the time-weighted bodyweight normalized surface area exposed is calculated from surface area, exposure duration, and body weight for each of 5 age periods, age 1 to 6, per USEPA, 1992.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 19989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$SA_{adj} = \text{Sum}(SA_i \times ED / BW_i)$
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K-21, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.024	1	1.0E-05	0.0002	1.5E-07	1.75	1.79	1.8E-05	2.6E-07	1.8E-05
					SUMMARY CANCER RISK			**2E-05**	**3E-07**	**2E-05**

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

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TABLE K-21, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.024	1	1.4E-04	0.0002	2.1E-06	0.0003	0.000294	4.8E-01	7.0E-03	4.9E-01
Calcium	15.6	1	9.3E-02	0.0002	1.3E-03	ND	ND			
Potassium	3.26	1	2.0E-02	0.0002	2.8E-04	ND	ND			
Manganese	1.43	1	8.6E-03	0.0002	1.2E-04	0.005	0.0002	1.7E+00	6.2E-01	2.3E+00
Zinc	0.0358	1	2.1E-04	0.0002	3.1E-06	0.3	0.102	7.2E-04	3.0E-05	7.5E-04
Trichlorofluoromethane	0.0021	1	1.3E-05	0.0163	1.5E-05	0.7	0.7	1.8E-05	2.1E-05	3.9E-05
SUMMARY HAZARD INDEX								2E+00	6E-01	3E+00

ND = No data available
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE K-22
INHALATION EXPOSURE TO VOCs DURING SHOWERING
CHILD EXPOSURE (SUBCHRONIC) – UNFILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION AIR	CA		ug/m^3	Modeled
CONVERSION FACTOR 1	CF1	24	hours/day	
EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
CONVERSION FACTOR 2	CF2	365	days/year	
AVERAGING TIME CANCER	AT	70	years	USEPA, 1989f
AVERAGING TIME NONCANCER	AT	5	years	USEPA, 1989f*

USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1989f. RAGs, Part A.

EQUATIONS

CANCER RISK = AVG. CONC. (ug/m^3) * CANCER UNIT RISK (ug/m^3)$^{-1}$

HAZARD QUOTIENT = AVG.CONC.(ug/m^3)/REF. CONC. (ug/m^3)

$$\text{AVG. CONC.} = \frac{\text{CAair * EF * ET * ED}}{\text{AT * CF1 * CF2}}$$

Note:
*For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. LIFETIME (ug/m^3)	INHALATION UNIT RISK (ug/m^3)$^{-1}$	CANCER RISK
No carcinogenic VOCs detected				
		SUMMARY CANCER RISK		0E+00

NONCARCINOGENIC EFFECTS

COMPOUND	AIR CONCENTRATION (ug/m^3)	AVE. CONC. FOR TIME PERIOD (ug/m^3)	INHALATION RfC (ug/m^3)	HAZARD QUOTIENT
Trichlorofluoromethane	9.2E+00	7.4E-02	7.0E+03	1.1E-05
		SUMMARY HAZARD INDEX		0.00001

ND = No data available

TABLE K-23
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3 cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE K–23, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg–day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg–day)	ORAL CSF [1] (mg/kg–day)^–1	DERMAL CSF (mg/kg–day)^–1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
No carcinogenic compound detected										
					SUMMARY CANCER RISK			0E+00	0E+00	0E+00

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

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TABLE K-23, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD [1] (mg/kg-day)	DERMAL RfD (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Calcium	16.9	1	9.3E-02	0.0002	9.0E-04	ND	ND			
Manganese	1.85	1	1.0E-02	0.0002	9.8E-05	0.005	0.0002	2.0E+00	4.9E-01	2.5E+00
Zinc	0.0288	1	1.6E-04	0.0002	1.5E-06	0.3	0.102	5.3E-04	1.5E-05	5.4E-04
					SUMMARY HAZARD INDEX			2E+00	5E-01	3E+00

ND = No data available
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-24
GROUNDWATER - INGESTION AND CONTACT DURING SHOWERING
CHILD EXPOSURE - (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL - WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] In estimating the dermally absorbed dose for children age 1 to 6, the time-weighted bodyweight normalized surface area exposed is calculated from surface area, exposure duration, and body weight for each of 5 age periods, age 1 to 6, per USEPA, 1992.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 19989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365 \text{ days/yr}}$$

Where:
$SA_{adj} = \text{Sum}(SA_i \times ED / BW_i)$
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE K-24, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF [1] (mg/kg-day) ^-1	DERMAL CSF (mg/kg-day) ^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
No carcinogenic compounds detected										
					SUMMARY CANCER RISK			0E+00	0E+00	0E+00

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE K–24, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg–day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg–day)	ORAL RfD [2] (mg/kg–day)	DERMAL RfD (mg/kg–day)^–1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Calcium	16.9	1	1.0E–01	0.0002	1.5E–03	ND	ND			
Manganese	1.85	1	1.1E–02	0.0002	1.6E–04	0.005	0.0002	2.2E+00	8.0E–01	3.0E+00
Zinc	0.0288	1	1.7E–04	0.0002	2.5E–06	0.3	0.102	5.8E–04	2.4E–05	6.0E–04
SUMMARY HAZARD INDEX								2E+00	8E–01	3E+00

ND = No data available
[2] Calculated from Oral RfD as described in Section 6.1.2.3.

TABLE K-25
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	54	g/day	USEPA, 1991b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	70	kg	USEPA, 1991b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-25, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.331	1.3	5.2E-05	2.1E-04	1.75	9.2E-05	3.6E-04
					SUMMARY CANCER RISK	9E-05	4E-04

TABLE K-25, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.331	1.3	1.2E-04	4.8E-04	0.0003	4.1E-01	1.6E+00
Manganese	63.2	94.7	2.3E-02	3.5E-02	0.14	1.7E-01	2.5E-01
Barium	2.76	4.4	1.0E-03	1.6E-03	0.07	1.5E-02	2.3E-02
Nickel	ND	ND					
Iron	79.72	130	2.9E-02	4.8E-02	ND		
					SUMMARY HAZARD INDEX	6E-01	2E+00

ND = No data available

TABLE K-26

FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	16.5	g/day	USEPA, 1989b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	16	kg	USEPA, 1989b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	ASSUMPTION
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989b. "EXPOSURE FACTORS HANDBOOK".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CF x IR x RAF x FI x C x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-26, continued

FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)

CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS

LANDFILL-RELATED COPCs

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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.331	1.3	1.2E-05	4.6E-05	1.75	2.0E-05	8.0E-05
					SUMMARY CANCER RISK	2E-05	8E-05

TABLE K-26, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.331	1.3	1.6E-04	6.4E-04	0.0003	5.5E-01	2.1E+00
Manganese	63.2	94.7	3.1E-02	4.7E-02	0.14	2.2E-01	3.3E-01
Barium	2.76	4.4	1.4E-03	2.2E-03	0.07	1.9E-02	3.1E-02
Nickel	ND	ND					
Iron	79.72	130	3.9E-02	6.4E-02	ND		
					SUMMARY HAZARD INDEX	8E-01	3E+00

ND = No data available

TABLE K-27

FISH INGESTION – PLOW SHOP POND – WHOLE FISH (BLUEGILLS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK – ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	54	g/day	USEPA, 1991b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	70	kg	USEPA, 1991b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-27, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.331	1.3	5.2E-05	2.1E-04	1.75	9.2E-05	3.6E-04
P,P-DDE	0.013	0.029	2.1E-06	4.6E-06	0.34	7.0E-07	1.6E-06
				SUMMARY CANCER RISK		9E-05	4E-04

TABLE K-27, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.33	1.3	1.2E-04	4.8E-04	0.0003	4.1E-01	1.6E+00
P,P-DDE	0.013	0.029	4.8E-06	1.1E-05	0.0005	9.6E-03	2.1E-02
Manganese	63.2	94.7	2.3E-02	3.5E-02	0.14	1.7E-01	2.5E-01
Zinc	25.02	29.6	9.3E-03	1.1E-02	0.3	3.1E-02	3.6E-02
Lead	0.072	0.16	2.7E-05	5.9E-05	ND		
Aluminum	2.58	4.5	9.5E-04	1.7E-03	ND		
Barium	2.76	4.4	1.0E-03	1.6E-03	0.07	1.5E-02	2.3E-02
Calcium	31940	48800	1.2E+01	1.8E+01	ND		
Chromium III	0.66	0.93	2.4E-04	3.4E-04	1	2.4E-04	3.4E-04
Cobalt	0.11	0.16	4.1E-05	5.9E-05	ND		
Copper	0.51	0.6	1.9E-04	2.2E-04	ND		
Iron	79.72	130	2.9E-02	4.8E-02	ND		
Mercury	0.37	0.54	1.4E-04	2.0E-04	0.0003	4.6E-01	6.7E-01
Selenium	0.67	0.55	2.5E-04	2.0E-04	0.005	5.0E-02	4.1E-02
Sodium	1794	2290	6.6E-01	8.5E-01	ND		
Magnesium	568	754	2.1E-01	2.8E-01	ND		
Thallium	0.06	0.1	2.2E-05	3.7E-05	0.00007	3.2E-01	5.3E-01
Cadmium	ND	ND					
Nickel	ND	ND					
				SUMMARY HAZARD INDEX		1E+00	3E+00

ND = No data available

TABLE K-28
FISH INGESTION – PLOW SHOP POND – WHOLE FISH (BLUEGILLS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK – ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	16.5	g/day	USEPA, 1989b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	16	kg	USEPA, 1989b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	ASSUMPTION
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989b. "EXPOSURE FACTORS HANDBOOK".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-28, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.331	1.3	1.2E-05	4.6E-05	1.75	2.0E-05	8.0E-05
P,P-DDE	0.013	0.029	4.6E-07	1.0E-06	0.34	1.6E-07	3.5E-07
					SUMMARY CANCER RISK	2E-05	8E-05

TABLE K-28, continued
FISH INGESTION - PLOW SHOP POND - WHOLE FISH (BLUEGILLS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.33	1.3	1.6E-04	6.4E-04	0.0003	5.4E-01	2.1E+00
P,P-DDE	0.013	0.029	6.4E-06	1.4E-05	0.0005	1.3E-02	2.9E-02
Manganese	63.2	94.7	3.1E-02	4.7E-02	0.14	2.2E-01	3.3E-01
Zinc	25.02	29.6	1.2E-02	1.5E-02	0.3	4.1E-02	4.9E-02
Lead	0.072	0.16	3.6E-05	7.9E-05	ND		
Aluminum	2.58	4.5	1.3E-03	2.2E-03	ND		
Barium	2.76	4.4	1.4E-03	2.2E-03	0.07	1.9E-02	3.1E-02
Calcium	31940	48800	1.6E+01	2.4E+01	ND		
Chromium III	0.66	0.93	3.3E-04	4.6E-04	1	3.3E-04	4.6E-04
Cobalt	0.11	0.16	5.4E-05	7.9E-05	ND		
Copper	0.51	0.6	2.5E-04	3.0E-04	ND		
Iron	79.72	130	3.9E-02	6.4E-02	ND		
Mercury	0.37	0.54	1.8E-04	2.7E-04	0.0003	6.1E-01	8.9E-01
Selenium	0.67	0.55	3.3E-04	2.7E-04	0.005	6.6E-02	5.4E-02
Sodium	1794	2290	8.9E-01	1.1E+00	ND		
Magnesium	568	754	2.8E-01	3.7E-01	ND		
Thallium	0.06	0.1	3.0E-05	4.9E-05	0.00007	4.2E-01	7.1E-01
Cadmium	ND	ND					
Nickel	ND	ND					
				SUMMARY HAZARD INDEX		2E+00	4E+00

ND = No data available

TABLE K-29

FISH INGESTION – PLOW SHOP POND – FILLETS (BULLHEAD, BASS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	54	g/day	USEPA, 1991b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	70	kg	USEPA, 1991b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-29, continued
FISH INGESTION – PLOW SHOP POND – FILLETS (BULLHEAD, BASS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.05	0.15	7.9E-06	2.4E-05	1.75	1.4E-05	4.2E-05
					SUMMARY CANCER RISK	1E-05	4E-05

TABLE K-29, continued
FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.05	0.15	1.8E-05	5.5E-05	0.0003	6.2E-02	1.8E-01
Manganese	0.16	0.3	5.9E-05	1.1E-04	0.14	4.2E-04	7.9E-04
Barium	ND	ND					
Nickel	ND	ND					
Iron	8.19	27	3.0E-03	1.0E-02	ND		
					SUMMARY HAZARD INDEX	6E-02	2E-01

ND = No data available

TABLE K-30
FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	16.5	g/day	USEPA, 1989b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	16	kg	USEPA, 1989b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	ASSUMPTION
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989b. "EXPOSURE FACTORS HANDBOOK".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-30, continued
FISH INGESTION – PLOW SHOP POND – FILLETS (BULLHEAD, BASS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.05	0.15	1.8E-06	5.3E-06	1.75	3.1E-06	9.3E-06
					SUMMARY CANCER RISK	3E-06	9E-06

TABLE K-30, continued
FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.05	0.15	2.5E-05	7.4E-05	0.0003	8.2E-02	2.5E-01
Manganese	0.16	0.3	7.9E-05	1.5E-04	0.14	5.7E-04	1.1E-03
Barium	ND	ND					
Nickel	ND	ND					
Iron	8.19	27	4.0E-03	1.3E-02	ND		
SUMMARY HAZARD INDEX						8E-02	2E-01

ND = No data available

TABLE K-31
FISH INGESTION – PLOW SHOP POND – FILLETS (BULLHEAD, BASS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK – ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	54	g/day	USEPA, 1991b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	70	kg	USEPA, 1991b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-31, continued
FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.05	0.15	7.9E-06	2.4E-05	1.75	1.4E-05	4.2E-05
P,P-DDE	0.0097	0.031	1.5E-06	4.9E-06	0.34	5.2E-07	1.7E-06
SUMMARY CANCER RISK						1E-05	4E-05

TABLE K-31, continued
FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.05	0.15	1.8E-05	5.5E-05	0.0003	6.2E-02	1.8E-01
P,P-DDE	0.0097	0.031	3.6E-06	1.1E-05	0.0005	7.2E-03	2.3E-02
Manganese	0.16	0.3	5.9E-05	1.1E-04	0.14	4.2E-04	7.9E-04
Zinc	4.48	6.1	1.7E-03	2.3E-03	0.3	5.5E-03	7.5E-03
Calcium	171	627	6.3E-02	2.3E-01	ND		
Chromium III	0.12	0.24	4.4E-05	8.9E-05	1	4.4E-05	8.9E-05
Cobalt	0.056	0.11	2.1E-05	4.1E-05	ND		
Copper	0.17	0.24	6.3E-05	8.9E-05	ND		
Iron	8.19	27	3.0E-03	1.0E-02	ND		
Mercury	1.14	4	4.2E-04	1.5E-03	0.0003	1.4E+00	4.9E+00
Selenium	0.12	0.2	4.4E-05	7.4E-05	0.005	8.9E-03	1.5E-02
Sodium	421	509	1.6E-01	1.9E-01	ND		
Magnesium	279	344	1.0E-01	1.3E-01	ND		
Barium	ND	ND					
Cadmium	ND	ND					
Nickel	ND	ND					
				SUMMARY HAZARD INDEX		1E+00	5E+00

ND = No data available

TABLE K-32

FISH INGESTION – PLOW SHOP POND – FILLETS (BULLHEAD, BASS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK – ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	16.5	g/day	USEPA, 1989b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.5		ASSUMPTION
BODY WEIGHT	BW	16	kg	USEPA, 1989b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	ASSUMPTION
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f

USEPA, 1991b. "STANDARD DEFAULT EXPOSURE FACTORS".
USEPA, 1989b. "EXPOSURE FACTORS HANDBOOK".
USEPA, 1989f. "RISK ASSESSMENT GUIDANCE FOR SUPERFUND".

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-32, continued

FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.05	0.15	1.8E-06	5.3E-06	1.75	3.1E-06	9.3E-06
P,P-DDE	0.0097	0.031	3.4E-07	1.1E-06	0.34	1.2E-07	3.7E-07
SUMMARY CANCER RISK						3E-06	1E-05

TABLE K-32, continued
FISH INGESTION - PLOW SHOP POND - FILLETS (BULLHEAD, BASS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
TOTAL RISK - ALL COPCs
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FEASIBILITY STUDY FOR GROUP 1A SITES
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.05	0.15	2.5E-05	7.4E-05	0.0003	8.2E-02	2.5E-01
P,P-DDE	0.0097	0.031	4.8E-06	1.5E-05	0.0005	9.6E-03	3.1E-02
Manganese	0.16	0.3	7.9E-05	1.5E-04	0.14	5.7E-04	1.1E-03
Zinc	4.48	6.1	2.2E-03	3.0E-03	0.3	7.4E-03	1.0E-02
Calcium	171	627	8.5E-02	3.1E-01	ND		
Chromium III	0.12	0.24	5.9E-05	1.2E-04	1	5.9E-05	1.2E-04
Cobalt	0.056	0.11	2.8E-05	5.4E-05	ND		
Copper	0.17	0.24	8.4E-05	1.2E-04	ND		
Iron	8.19	27	4.0E-03	1.3E-02	ND		
Mercury	1.14	4	5.6E-04	2.0E-03	0.0003	1.9E+00	6.6E+00
Selenium	0.12	0.2	5.9E-05	9.9E-05	0.005	1.2E-02	2.0E-02
Sodium	421	509	2.1E-01	2.5E-01	ND		
Magnesium	279	344	1.4E-01	1.7E-01	ND		
Barium	ND	ND					
Cadmium	ND	ND					
Nickel	ND	ND					
					SUMMARY HAZARD INDEX	2E+00	7E+00

ND = No data available

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TABLE K-33
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – AVERAGE EXPOSURE – CURRENT LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	26	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.

[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM\ (SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-33, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND - AVERAGE EXPOSURE - CURRENT LAND USE
LANDFILL-RELATED COPCs
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	467	1	1.1E-05	0.01	2.0E-06	1.75E+00	2.0E-05	1.79E+00	3.6E-06	2.3E-05
					SUMMARY CANCER RISK		2E-05		4E-06	2E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

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TABLE K-33, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – AVERAGE EXPOSURE – CURRENT LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	467	1	7.9E-05	0.01	1.4E-05	0.0003	2.6E-01	0.000294	4.8E-02	3.1E-01
Barium	108	1	1.8E-05	0.01	3.3E-06	0.07	2.6E-04	0.0049	6.7E-04	9.3E-04
Manganese	2639	1	4.5E-04	0.01	8.0E-05	0.14	3.2E-03	0.0056	1.4E-02	1.7E-02
Nickel	23	1	3.9E-06	0.01	7.0E-07	0.02	2.0E-04	0.001	7.0E-04	8.9E-04
Iron	36314	1	6.2E-03	0.01	1.1E-03	ND		ND		
					SUMMARY HAZARD INDEX		3E-01		6E-02	3E-01

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE K-34
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND - MAXIMUM EXPOSURE - CURRENT LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm^2-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^2	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	26	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365\ \text{days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM(SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-34, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – MAXIMUM EXPOSURE – CURRENT LAND USE
LANDFILL-RELATED COPCs
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FORT DEVENS, MA
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	3200	1	7.8E-05	0.01	1.4E-05	1.75E+00	1.4E-04	1.79E+00	2.5E-05	1.6E-04
					SUMMARY CANCER RISK		1E-04		2E-05	2E-04

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE K-34, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND - MAXIMUM EXPOSURE - CURRENT LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	3200	1	5.4E-04	0.01	9.7E-05	0.0003	1.8E+00	0.000294	3.3E-01	2.1E+00
Barium	344	1	5.8E-05	0.01	1.0E-05	0.07	8.3E-04	0.0049	2.1E-03	3.0E-03
Manganese	54800	1	9.3E-03	0.01	1.7E-03	0.14	6.6E-02	0.0056	3.0E-01	3.6E-01
Nickel	79.3	1	1.3E-05	0.01	2.4E-06	0.02	6.7E-04	0.001	2.4E-03	3.1E-03
Iron	330000	1	5.6E-02	0.01	1.0E-02	ND		ND		
					SUMMARY HAZARD INDEX		2E+00		6E-01	3E+00

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE K-35
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – AVERAGE EXPOSURE – FUTURE LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	100	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.

[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = \text{SUM}(SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-35, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – AVERAGE EXPOSURE – FUTURE LAND USE
LANDFILL-RELATED COPCs
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FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	467	1	4.4E-05	0.01	7.8E-06	1.75E+00	7.6E-05	1.79E+00	1.4E-05	9.0E-05
					SUMMARY CANCER RISK		8E-05		1E-05	9E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE K-35, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – AVERAGE EXPOSURE – FUTURE LAND USE
LANDFILL-RELATED COPCs
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	467	1	3.0E-04	0.01	5.4E-05	0.0003	1.0E+00	0.000294	1.8E-01	1.2E+00
Barium	108	1	7.0E-05	0.01	1.3E-05	0.07	1.0E-03	0.0049	2.6E-03	3.6E-03
Manganese	2639	1	1.7E-03	0.01	3.1E-04	0.14	1.2E-02	0.0056	5.5E-02	6.7E-02
Nickel	23	1	1.5E-05	0.01	2.7E-06	0.02	7.5E-04	0.001	2.7E-03	3.4E-03
Iron	36314	1	2.4E-02	0.01	4.2E-03	ND		ND		
					SUMMARY HAZARD INDEX		1E+00		2E-01	1E+00

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE K-36
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND - MAXIMUM EXPOSURE - FUTURE LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	100	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.

[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM(SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-36, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – MAXIMUM EXPOSURE – FUTURE LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	3200	1	3.0E-04	0.01	5.3E-05	1.75E+00	5.2E-04	1.79E+00	9.5E-05	6.2E-04
					SUMMARY CANCER RISK		5E-04		1E-04	6E-04

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE K-36, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – MAXIMUM EXPOSURE – FUTURE LAND USE
LANDFILL-RELATED COPCs
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	3200	1	2.1E-03	0.01	3.7E-04	0.0003	7.0E+00	0.000294	1.3E+00	8.2E+00
Barium	344	1	2.2E-04	0.01	4.0E-05	0.07	3.2E-03	0.0049	8.2E-03	1.1E-02
Manganese	54800	1	3.6E-02	0.01	6.4E-03	0.14	2.6E-01	0.0056	1.1E+00	1.4E+00
Nickel	79.3	1	5.2E-05	0.01	9.2E-06	0.02	2.6E-03	0.001	9.2E-03	1.2E-02
Iron	330000	1	2.2E-01	0.01	3.8E-02	ND		ND		
					SUMMARY HAZARD INDEX		7E+00		2E+00	1E+01

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE K-37
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – AVERAGE EXPOSURE – CURRENT LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	26	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM (SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-37, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND - AVERAGE EXPOSURE - CURRENT LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	467	1	1.1E-05	0.01	2.0E-06	1.75E+00	2.0E-05	1.79E+00	3.6E-06	2.3E-05
Beryllium	0.53	1	1.3E-08	0.01	2.3E-09	4.30E+00	5.5E-08	4.30E+02	9.8E-07	1.0E-06
Benzo(a)anthracene	0.22	1	5.3E-09	0.05	4.7E-09	7.30E+00	3.9E-08	8.02E+00	3.8E-08	7.7E-08
Chrysene	0.32	1	7.8E-09	0.05	6.9E-09	7.30E+00	5.7E-08	8.02E+00	5.5E-08	1.1E-07
P,P-DDE	0.05	0.3	3.6E-10	0.05	1.1E-09	3.40E-01	1.2E-10	1.70E+00	1.8E-09	2.0E-09
P,P-DDD	0.07	0.3	5.1E-10	0.05	1.5E-09	2.40E-01	1.2E-10	1.20E+00	1.8E-09	1.9E-09
P,P-DDT	0.03	0.3	2.2E-10	0.05	6.5E-10	3.40E-01	7.4E-11	1.70E+00	1.1E-09	1.2E-09
					SUMMARY CANCER RISK		2E-05		5E-06	2E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE K-37, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – AVERAGE EXPOSURE – CURRENT LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	467	1	7.9E-05	0.01	1.4E-05	0.0003	2.6E-01	0.000294	4.8E-02	3.1E-01
Barium	108	1	1.8E-05	0.01	3.3E-06	0.07	2.6E-04	0.0049	6.7E-04	9.3E-04
Manganese	2639	1	4.5E-04	0.01	8.0E-05	0.14	3.2E-03	0.0056	1.4E-02	1.7E-02
Nickel	23	1	3.9E-06	0.01	7.0E-07	0.02	2.0E-04	0.001	7.0E-04	8.9E-04
Iron	36314	1	6.2E-03	0.01	1.1E-03	ND		ND		
Beryllium	0.53	1	9.0E-08	0.01	1.6E-08	0.005	1.8E-05	0.00005	3.2E-04	3.4E-04
Benzo(a)anthracene	0.22	1	3.7E-08	0.05	3.3E-08	0.04	9.3E-07	0.04	8.3E-07	1.8E-06
Chrysene	0.32	1	5.4E-08	0.05	4.8E-08	0.04	1.4E-06	0.04	1.2E-06	2.6E-06
P,P-DDE	0.05	0.3	2.5E-09	0.05	7.6E-09	0.0005	5.1E-06	0.0001	7.6E-05	8.1E-05
P,P-DDD	0.07	0.3	3.6E-09	0.05	1.1E-08	0.0005	7.1E-06	0.0001	1.1E-04	1.1E-04
P,P-DDT	0.03	0.3	1.5E-09	0.05	4.5E-09	0.0005	3.1E-06	0.0001	4.5E-05	4.8E-05
Fluoranthene	0.5	1	8.5E-08	0.05	7.6E-08	0.04	2.1E-06	0.0364	2.1E-06	4.2E-06
Naphthalene	0.32	1	5.4E-08	0.05	4.8E-08	0.04	1.4E-06	0.04	1.2E-06	2.6E-06
Phenanthrene	0.38	1	6.4E-08	0.05	5.7E-08	0.04	1.6E-06	0.04	1.4E-06	3.0E-06
Pyrene	0.97	1	1.6E-07	0.05	1.5E-07	0.03	5.5E-06	0.0273	5.4E-06	1.1E-05
Aluminum	7938	1	1.3E-03	0.01	2.4E-04	ND		ND		
Cadmium	9.8	1	1.7E-06	0.01	3.0E-07	0.001	1.7E-03	0.00001	3.0E-02	3.1E-02
Calcium	8074	1	1.4E-03	0.01	2.4E-04	ND		ND		
Cobalt	5.8	1	9.8E-07	0.01	1.8E-07	ND		ND		
Chromium III	1788.3	1	3.0E-04	0.01	5.4E-05	1	3.0E-04	0.1	5.4E-04	8.4E-04
Chromium VI	198.7	1	3.4E-05	0.01	6.0E-06	0.005	6.7E-03	0.00055	1.1E-02	1.8E-02
Copper	39.7	1	6.7E-06	0.01	1.2E-06	ND		ND		
Lead	125	0.3	6.4E-06	0.01	3.8E-06	ND		ND		
Magnesium	1629	1	2.8E-04	0.01	4.9E-05	ND		ND		
Mercury	18.2	1	3.1E-06	0.01	5.5E-07	0.0003	1.0E-02	0.00006	9.2E-03	1.9E-02
Potassium	435	1	7.4E-05	0.01	1.3E-05	ND		ND		
Selenium	1.95	1	3.3E-07	0.01	5.9E-08	0.005	6.6E-05	0.003	2.0E-05	8.6E-05
Sodium	1113	1	1.9E-04	0.01	3.4E-05	ND		ND		
Vanadium	24.6	1	4.2E-06	0.01	7.4E-07	0.007	6.0E-04	0.00021	3.5E-03	4.1E-03
Zinc	88.6	1	1.5E-05	0.01	2.7E-06	0.3	5.0E-05	0.102	2.6E-05	7.6E-05
					SUMMARY HAZARD INDEX		3E-01		1E-01	4E-01

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

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TABLE K-38
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – MAXIMUM EXPOSURE – CURRENT LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	26	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM\ (SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-38, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – MAXIMUM EXPOSURE – CURRENT LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	3200	1	7.8E-05	0.01	1.4E-05	1.75E+00	1.4E-04	1.79E+00	2.5E-05	1.6E-04
Beryllium	2.72	1	6.6E-08	0.01	1.2E-08	4.30E+00	2.8E-07	4.30E+02	5.1E-06	5.3E-06
Benzo(a)anthracene	1.1	1	2.7E-08	0.05	2.4E-08	7.30E+00	1.9E-07	8.02E+00	1.9E-07	3.9E-07
Chrysene	1.5	1	3.6E-08	0.05	3.2E-08	7.30E+00	2.7E-07	8.02E+00	2.6E-07	5.3E-07
P,P-DDE	1.3	0.3	9.4E-09	0.05	2.8E-08	3.40E-01	3.2E-09	1.70E+00	4.8E-08	5.1E-08
P,P-DDD	1.8	0.3	1.3E-08	0.05	3.9E-08	2.40E-01	3.1E-09	1.20E+00	4.7E-08	5.0E-08
P,P-DDT	0.13	0.3	9.4E-10	0.05	2.8E-09	3.40E-01	3.2E-10	1.70E+00	4.8E-09	5.1E-09
					SUMMARY CANCER RISK		1E-04		3E-05	2E-04

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE K-38, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – MAXIMUM EXPOSURE – CURRENT LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	3200	1	5.4E-04	0.01	9.7E-05	0.0003	1.8E+00	0.000294	3.3E-01	2.1E+00
Barium	344	1	5.8E-05	0.01	1.0E-05	0.07	8.3E-04	0.0049	2.1E-03	3.0E-03
Manganese	54800	1	9.3E-03	0.01	1.7E-03	0.14	6.6E-02	0.0056	3.0E-01	3.6E-01
Nickel	79.3	1	1.3E-05	0.01	2.4E-06	0.02	6.7E-04	0.001	2.4E-03	3.1E-03
Iron	330000	1	5.6E-02	0.01	1.0E-02	ND		ND		
Beryllium	2.72	1	4.6E-07	0.01	8.2E-08	0.005	9.2E-05	0.00005	1.6E-03	1.7E-03
Benzo(a)anthracene	1.1	1	1.9E-07	0.05	1.7E-07	0.04	4.7E-06	0.04	4.2E-06	8.8E-06
Chrysene	1.5	1	2.5E-07	0.05	2.3E-07	0.04	6.4E-06	0.04	5.7E-06	1.2E-05
P,P-DDE	1.3	0.3	6.6E-08	0.05	2.0E-07	0.0005	1.3E-04	0.0001	2.0E-03	2.1E-03
P,P-DDD	1.8	0.3	9.2E-08	0.05	2.7E-07	0.0005	1.8E-04	0.0001	2.7E-03	2.9E-03
P,P-DDT	0.13	0.3	6.6E-09	0.05	2.0E-08	0.0005	1.3E-05	0.0001	2.0E-04	2.1E-04
Fluoranthene	3.4	1	5.8E-07	0.05	5.1E-07	0.04	1.4E-05	0.0364	1.4E-05	2.9E-05
Naphthalene	1.6	1	2.7E-07	0.05	2.4E-07	0.04	6.8E-06	0.04	6.0E-06	1.3E-05
Phenanthrene	2.5	1	4.2E-07	0.05	3.8E-07	0.04	1.1E-05	0.04	9.4E-06	2.0E-05
Pyrene	4.35	1	7.4E-07	0.05	6.6E-07	0.03	2.5E-05	0.0273	2.4E-05	4.9E-05
Aluminum	24000	1	4.1E-03	0.01	7.3E-04	ND		ND		
Cadmium	60	1	1.0E-05	0.01	1.8E-06	0.001	1.0E-02	0.00001	1.8E-01	1.9E-01
Calcium	20100	1	3.4E-03	0.01	6.1E-04	ND		ND		
Cobalt	58.7	1	1.0E-05	0.01	1.8E-06	ND		ND		
Chromium III	9000	1	1.5E-03	0.01	2.7E-04	1	1.5E-03	0.1	2.7E-03	4.2E-03
Chromium VI	1000	1	1.7E-04	0.01	3.0E-05	0.005	3.4E-02	0.00055	5.5E-02	8.9E-02
Copper	132	1	2.2E-05	0.01	4.0E-06	ND		ND		
Lead	632	0.3	3.2E-05	0.01	1.9E-05	ND		ND		
Magnesium	6900	1	1.2E-03	0.01	2.1E-04	ND		ND		
Mercury	130	1	2.2E-05	0.01	3.9E-06	0.0003	7.3E-02	0.00006	6.5E-02	1.4E-01
Potassium	2350	1	4.0E-04	0.01	7.1E-05	ND		ND		
Selenium	6.6	1	1.1E-06	0.01	2.0E-07	0.005	2.2E-04	0.003	6.6E-05	2.9E-04
Sodium	2870	1	4.9E-04	0.01	8.7E-05	ND		ND		
Vanadium	166	1	2.8E-05	0.01	5.0E-06	0.007	4.0E-03	0.00021	2.4E-02	2.8E-02
Zinc	403	1	6.8E-05	0.01	1.2E-05	0.3	2.3E-04	0.102	1.2E-04	3.5E-04
					SUMMARY HAZARD INDEX		2E+00		1E+00	3E+00

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE K-39
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – AVERAGE EXPOSURE – FUTURE LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

SDPLTRFA	15-Dec-93

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	100	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM\ (SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

TABLE K-39, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – AVERAGE EXPOSURE – FUTURE LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	467	1	4.4E-05	0.01	7.8E-06	1.75E+00	7.6E-05	1.79E+00	1.4E-05	9.0E-05
Beryllium	0.53	1	4.9E-08	0.01	8.8E-09	4.30E+00	2.1E-07	4.30E+02	3.8E-06	4.0E-06
Benzo(a)anthracene	0.22	1	2.1E-08	0.05	1.8E-08	7.30E+00	1.5E-07	8.02E+00	1.5E-07	3.0E-07
Chrysene	0.32	1	3.0E-08	0.05	2.7E-08	7.30E+00	2.2E-07	8.02E+00	2.1E-07	4.3E-07
P,P-DDE	0.05	0.3	1.4E-09	0.05	4.2E-09	3.40E-01	4.8E-10	1.70E+00	7.1E-09	7.5E-09
P,P-DDD	0.07	0.3	2.0E-09	0.05	5.8E-09	2.40E-01	4.7E-10	1.20E+00	7.0E-09	7.4E-09
P,P-DDT	0.03	0.3	8.4E-10	0.05	2.5E-09	3.40E-01	2.9E-10	1.70E+00	4.2E-09	4.5E-09
					SUMMARY CANCER RISK		8E-05		2E-05	9E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] *Calculated from Oral CSFs as described in Section 6.1.2.3.*

TABLE K-39, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
PLOW SHOP POND – AVERAGE EXPOSURE – FUTURE LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	467	1	3.0E-04	0.01	5.4E-05	0.0003	1.0E+00	0.000294	1.8E-01	1.2E+00
Barium	108	1	7.0E-05	0.01	1.3E-05	0.07	1.0E-03	0.0049	2.6E-03	3.6E-03
Manganese	2639	1	1.7E-03	0.01	3.1E-04	0.14	1.2E-02	0.0056	5.5E-02	6.7E-02
Nickel	23	1	1.5E-05	0.01	2.7E-06	0.02	7.5E-04	0.001	2.7E-03	3.4E-03
Iron	36314	1	2.4E-02	0.01	4.2E-03	ND		ND		
Beryllium	0.53	1	3.5E-07	0.01	6.2E-08	0.005	6.9E-05	0.00005	1.2E-03	1.3E-03
Benzo(a)anthracene	0.22	1	1.4E-07	0.05	1.3E-07	0.04	3.6E-06	0.04	3.2E-06	6.8E-06
Chrysene	0.32	1	2.1E-07	0.05	1.9E-07	0.04	5.2E-06	0.04	4.6E-06	9.9E-06
P,P-DDE	0.05	0.3	9.8E-09	0.05	2.9E-08	0.0005	2.0E-05	0.0001	2.9E-04	3.1E-04
P,P-DDD	0.07	0.3	1.4E-08	0.05	4.1E-08	0.0005	2.7E-05	0.0001	4.1E-04	4.3E-04
P,P-DDT	0.03	0.3	5.9E-09	0.05	1.7E-08	0.0005	1.2E-05	0.0001	1.7E-04	1.9E-04
Fluoranthene	0.5	1	3.3E-07	0.05	2.9E-07	0.04	8.2E-06	0.0364	8.0E-06	1.6E-05
Naphthalene	0.32	1	2.1E-07	0.05	1.9E-07	0.04	5.2E-06	0.04	4.6E-06	9.9E-06
Phenanthrene	0.38	1	2.5E-07	0.05	2.2E-07	0.04	6.2E-06	0.04	5.5E-06	1.2E-05
Pyrene	0.97	1	6.3E-07	0.05	5.6E-07	0.03	2.1E-05	0.0273	2.1E-05	4.2E-05
Aluminum	7938	1	5.2E-03	0.01	9.2E-04	ND		ND		
Cadmium	9.8	1	6.4E-06	0.01	1.1E-06	0.001	6.4E-03	0.00001	1.1E-01	1.2E-01
Calcium	8074	1	5.3E-03	0.01	9.4E-04	ND		ND		
Cobalt	5.8	1	3.8E-06	0.01	6.7E-07	ND		ND		
Chromium III	1788.3	1	1.2E-03	0.01	2.1E-04	1	1.2E-03	0.1	2.1E-03	3.2E-03
Chromium VI	198.7	1	1.3E-04	0.01	2.3E-05	0.005	2.6E-02	0.00055	4.2E-02	6.8E-02
Copper	39.7	1	2.6E-05	0.01	4.6E-06	ND		ND		
Lead	125	0.3	2.4E-05	0.01	1.5E-05	ND		ND		
Magnesium	1629	1	1.1E-03	0.01	1.9E-04	ND		ND		
Mercury	18.2	1	1.2E-05	0.01	2.1E-06	0.0003	4.0E-02	0.00006	3.5E-02	7.5E-02
Potassium	435	1	2.8E-04	0.01	5.1E-05	ND		ND		
Selenium	1.95	1	1.3E-06	0.01	2.3E-07	0.005	2.5E-04	0.003	7.6E-05	3.3E-04
Sodium	1113	1	7.3E-04	0.01	1.3E-04	ND		ND		
Vanadium	24.6	1	1.6E-05	0.01	2.9E-06	0.007	2.3E-03	0.00021	1.4E-02	1.6E-02
Zinc	88.6	1	5.8E-05	0.01	1.0E-05	0.3	1.9E-04	0.102	1.0E-04	2.9E-04
					SUMMARY HAZARD INDEX		1E+00		5E-01	2E+00

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE K-40
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – MAXIMUM EXPOSURE – FUTURE LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	100	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* *Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.*

[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM(SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE K-40, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – MAXIMUM EXPOSURE – FUTURE LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	3200	1	3.0E-04	0.01	5.3E-05	1.75E+00	5.2E-04	1.79E+00	9.5E-05	6.2E-04
Beryllium	2.72	1	2.5E-07	0.01	4.5E-08	4.30E+00	1.1E-06	4.30E+02	1.9E-05	2.1E-05
Benzo(a)anthracene	1.1	1	1.0E-07	0.05	9.1E-08	7.30E+00	7.5E-07	8.02E+00	7.3E-07	1.5E-06
Chrysene	1.5	1	1.4E-07	0.05	1.2E-07	7.30E+00	1.0E-06	8.02E+00	1.0E-06	2.0E-06
P,P-DDE	1.3	0.3	3.6E-08	0.05	1.1E-07	3.40E-01	1.2E-08	1.70E+00	1.8E-07	2.0E-07
P,P-DDD	1.8	0.3	5.0E-08	0.05	1.5E-07	2.40E-01	1.2E-08	1.20E+00	1.8E-07	1.9E-07
P,P-DDT	0.13	0.3	3.6E-09	0.05	1.1E-08	3.40E-01	1.2E-09	1.70E+00	1.8E-08	2.0E-08
					SUMMARY CANCER RISK		5E-04		1E-04	6E-04

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE K-40, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
FLOW SHOP POND – MAXIMUM EXPOSURE – FUTURE LAND USE
TOTAL RISK; ALL COPCS
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	3200	1	2.1E-03	0.01	3.7E-04	0.0003	7.0E+00	0.000294	1.3E+00	8.2E+00
Barium	344	1	2.2E-04	0.01	4.0E-05	0.07	3.2E-03	0.0049	8.2E-03	1.1E-02
Manganese	54800	1	3.6E-02	0.01	6.4E-03	0.14	2.6E-01	0.0056	1.1E+00	1.4E+00
Nickel	79.3	1	5.2E-05	0.01	9.2E-06	0.02	2.6E-03	0.001	9.2E-03	1.2E-02
Iron	330000	1	2.2E-01	0.01	3.8E-02	ND		ND		
Beryllium	2.72	1	1.8E-06	0.01	3.2E-07	0.005	3.5E-04	0.00005	6.3E-03	6.7E-03
Benzo(a)anthracene	1.1	1	7.2E-07	0.05	6.4E-07	0.04	1.8E-05	0.04	1.6E-05	3.4E-05
Chrysene	1.5	1	9.8E-07	0.05	8.7E-07	0.04	2.4E-05	0.04	2.2E-05	4.6E-05
P,P-DDE	1.3	0.3	2.5E-07	0.05	7.6E-07	0.0005	5.1E-04	0.0001	7.6E-03	8.1E-03
P,P-DDD	1.8	0.3	3.5E-07	0.05	1.0E-06	0.0005	7.0E-04	0.0001	1.0E-02	1.1E-02
P,P-DDT	0.13	0.3	2.5E-08	0.05	7.6E-08	0.0005	5.1E-05	0.0001	7.6E-04	8.1E-04
Fluoranthene	3.4	1	2.2E-06	0.05	2.0E-06	0.04	5.5E-05	0.0364	5.4E-05	1.1E-04
Naphthalene	1.6	1	1.0E-06	0.05	9.3E-07	0.04	2.6E-05	0.04	2.3E-05	4.9E-05
Phenanthrene	2.5	1	1.6E-06	0.05	1.5E-06	0.04	4.1E-05	0.04	3.6E-05	7.7E-05
Pyrene	4.35	1	2.8E-06	0.05	2.5E-06	0.03	9.5E-05	0.0273	9.3E-05	1.9E-04
Aluminum	24000	1	1.6E-02	0.01	2.8E-03	ND		ND		
Cadmium	60	1	3.9E-05	0.01	7.0E-06	0.001	3.9E-02	0.00001	7.0E-01	7.4E-01
Calcium	20100	1	1.3E-02	0.01	2.3E-03	ND		ND		
Cobalt	58.7	1	3.8E-05	0.01	6.8E-06	ND		ND		
Chromium III	9000	1	5.9E-03	0.01	1.0E-03	1	5.9E-03	0.1	1.0E-02	1.6E-02
Chromium VI	1000	1	6.5E-04	0.01	1.2E-04	0.005	1.3E-01	0.00055	2.1E-01	3.4E-01
Copper	132	1	8.6E-05	0.01	1.5E-05	ND		ND		
Lead	632	0.3	1.2E-04	0.01	7.3E-05	ND		ND		
Magnesium	6900	1	4.5E-03	0.01	8.0E-04	ND		ND		
Mercury	130	1	8.5E-05	0.01	1.5E-05	0.0003	2.8E-01	0.00006	2.5E-01	5.3E-01
Potassium	2350	1	1.5E-03	0.01	2.7E-04	ND		ND		
Selenium	6.6	1	4.3E-06	0.01	7.7E-07	0.005	8.6E-04	0.003	2.6E-04	1.1E-03
Sodium	2870	1	1.9E-03	0.01	3.3E-04	ND		ND		
Vanadium	166	1	1.1E-04	0.01	1.9E-05	0.007	1.5E-02	0.00021	9.2E-02	1.1E-01
Zinc	403	1	2.6E-04	0.01	4.7E-05	0.3	8.8E-04	0.102	4.6E-04	1.3E-03
					SUMMARY HAZARD INDEX		8E+00		4E+00	1E+01

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

MODELING OF VOC CONCENTRATIONS IN SHOWER AIR FROM GROUNDWATER

SHEPLEY'S HILL LANDFILL

CALCULATION OF SHOWER-GENERATED AIR CONTAMINANTS FROM GROUNDWATER

ABB Environmental Services, Inc. (ABB-ES) calculated concentrations of volatile organic compounds (VOCs) in groundwater that could volatilize during a shower. After reviewing the literature, the model selected by ABB-ES to predict indoor (bathroom) concentrations is that presented by Foster and Chrostowski (1987). This theoretical approach is based on the experimental work of Andelman (1985). Andelman measured air concentrations of trichloroethylene and chloroform in a bench scale shower assembly. Foster and Chrostowski (1987) developed a model from these experimental data. ABB-ES modified the input parameters from the bench scale design to be representative of a typical bathroom.

The equation used to calculate air concentrations in the bathroom is shown below:

$$C(voc) = \frac{S}{R} \times (e^{RD_s} - 1) \times e^{-Rt} \qquad \text{(Eqn. 1)}$$

where:

C(voc) = concentration of VOC in bathroom (ug/m^3)
S = VOC generation rate (ug/m^3-min)
R = air exchange rate (min^{-1})
D_s = duration of shower (min)
t = time at which concentration is being calculated (min)

R, the air exchange rate, is calculated as the volumetric flowrate through the bathroom (m^3/min) divided by the volume of the bathroom (m^3).

S, the VOC source generation rate, is calculated based on the concentration of the contaminant in the water, emission of compound from a droplet, flowrate of water, and volume of room for dilution. S is calculated from the following series of equations:

$$S = \frac{C_{wd} \times FR}{SV} \qquad \text{(Eqn. 2)}$$

where:

C_{wd} = concentration in water droplet (ug/l)
FR = flow rate in shower (l/min)
SV = shower volume (m^3)

C_{wd} is calculated as follows:

$$C_{wd} = C_{wo} \times [1 - e^{(\frac{-K_{al} \times t_s}{60 \times d})}] \qquad \text{(Eqn. 3)}$$

where:

C_{wo} = concentration in groundwater (ug/l)
K_{al} = temperature correction of the mass transfer coefficient, Kl ((cm/hr)

t_s = shower water droplet free-fall time (sec)
d = droplet diameter (mm)

K_{al} is calculated according to:

$$K_{al} = K_L \times [\frac{T_1 \times u_s}{T_s \times u_1}]^{-0.5} \qquad \text{(Eqn. 4)}$$

where:

K_L = mass-transfer coefficient (cm/hr)
T_1 = reference temperature (K)
u_s = viscosity of water at reference temperature (cp)
T_s = temperature of shower water (K)
u_1 = viscosity of water at shower temperature (cp)

K_L is calculated according to:

$$K_L(voc) = \frac{1}{\frac{1}{k_l(voc)} + \frac{RT}{H \times k_g(voc)}} \quad \text{(Eqn. 5)}$$

where:

$k_l(voc)$ = chemical-specific liquid mass-transfer coefficient (cm/hr)
$k_g(voc)$ = chemical-specific gas mass-transfer coefficient (cm/hr)
RT = molecular gas constant (R) x temperature (T) (atm-m^3/mole)
H = Henry's Law Constant (atm-m^3/mole)

The input values of k_l and k_g are based on the mass transfer coefficients of CO_2 and water. They are calculated for the particular compound of interest according to the following equations:

$$k_l(voc) = k_l(CO_2) \times \left[\frac{44}{MW(voc)}\right]^{0.5} \quad \text{(Eqn. 6)}$$

$$k_g(voc) = k_g(H_2O) \times \left[\frac{18}{MW(voc)}\right]^{0.5} \quad \text{(Eqn. 7)}$$

where:

$k_l(CO_2)$ = liquid mass-transfer coefficient for carbon dioxide (cm/hr)
$k_g(H_2O)$ = gas mass-transfer coefficient for water (cm/hr)
MW(voc) = molecular weight of VOC

Several assumptions were made to complete this modeling effort. The more important ones involve the volume of the bathroom and the air exchange rate (see Equations 1 and 2). A bathroom volume of $12 m^3$ was assumed. For the purposes of this model, it was also assumed that the air between the shower area and the rest of the bathroom was well mixed. The volumetric flowrate through the bathroom was assumed to be 0.4 m^3/min, which gives an effective air exchange rate of 1.8 air changes/hour. Few measurements have been done on ventilation rate in bathrooms. ABB-ES considers this value to be a conservative estimate given that most homes have air exchange rates of 0.5 - 2.0 changes/hour. Bathrooms may have higher ventilation rates than the entire house due to the effect of local exhaust fans, if present, or the opening of windows.

Another assumption is implicit in the use of Equation 1. This equation calculates VOC concentrations at time (t), which is assumed to equal the duration of shower use (D_S). Thus, the resulting concentrations represent maximum concentrations at the end of the shower. In reality, an individual would experience an integrated exposure that would gradually increase during shower usage and decrease again after the water was turned off. ABB-ES made the simplifying assumption that the peak concentrations would persist for the duration of exposure. This is a conservative assumption that is protective of public health.

REFERENCES

Andelman, J.B., 1985. "Inhalation Exposure in the Home to Volatile Organic Contaminants in Drinking Water"; Sci. Total Environ.; Vol. 47, pp. 443-460.

Foster, S.A. and P.C. Chrostowski, 1987. "Inhalation Exposures to Volatile Organic Contaminants in the Shower"; paper presented at the 80th Annual Meeting of the Air Pollution Control Association; New York, New York; June 1987.

TABLE L-1
CONCENTRATION OF VOLATILE COMPOUNDS RESULTING FROM SHOWERING
SHEPLEY'S HILL LANDFILL – WELL GROUP 1
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
EMPIRICAL CONSTANTS

CONSTANT	SYMBOL	VALUE	UNIT	SOURCE
Liquid-film mass transfer for CO2	kl (CO2)	20	cm/hr	Calculated
Gas-film mass transfer for H2O	kg (H2O)	3000	cm/hr	Calculated
Molar gas constant x Temperature	RT	0.024	atm-m³/mole	Constant
Reference temperature	T1	293	°K	Constant
Temperature of shower water	Ts	318	°K	Assumption
Viscosity of water at shower temperature	μs	0.6178	cp	Calculated
Viscosity of water at reference temperature	μ1	0.65	cp	Calculated
Shower droplet free-fall time	ts	1.5	sec	Assumption
Droplet diameter	d	1	mm	Foster and Chrostowski, 1987
Flow rate in shower	FR	20	l/min	Assumption
Volume of shower area	SV	12	m³	Assumption
Air exchange rate	R	0.03	min⁻¹	Calculated
Time in shower	Ds	12	min	USEPA, 1989f
Time at which concentration is being calculated	t	12	min	USEPA, 1989f

Foster, S.A. and Chrostowski, P.C., 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower
USEPA, 1989f. Risk Assessment Guidance for Superfund

SHOWER CONCENTRATIONS

COMPOUND	Cwo (mg/l)	MW (g/mol)	H (atm-m³/mol)	kl (cm/hr)	kg (cm/hr)	Kl (cm/hr)	Kal (cm/hr)	Cwd (mg/l)	S (mg/m³-min)	Cvoc (mg/m³)
MAXIMUM CONCENTRATIONS										
Benzene	0.0017	78	5.60E-03	1.5E+01	1.4E+03	1.4E+01	1.5E+01	5.4E-04	9.0E-04	9.1E-03
Chloroethane	0.0055	65	1.11E-02	1.7E+01	1.6E+03	1.6E+01	1.7E+01	1.9E-03	3.2E-03	3.2E-02
1,1-Dichloroethane	0.0044	99	4.31E-03	1.3E+01	1.3E+03	1.3E+01	1.3E+01	1.3E-03	2.1E-03	2.1E-02
1,2-Dichloroethane	0.0099	99	9.78E-04	1.3E+01	1.3E+03	1.1E+01	1.1E+01	2.4E-03	4.1E-03	4.1E-02
1,2-Dichloropropane	0.00052	113	2.10E-03	1.2E+01	1.2E+03	1.1E+01	1.2E+01	1.3E-04	2.2E-04	2.3E-03
1,2-Dichloroethene	0.007	97	7.07E-03	1.3E+01	1.3E+03	1.3E+01	1.4E+01	2.1E-03	3.4E-03	3.5E-02
AVERAGE CONCENTRATIONS										
Benzene	0.00051	78	5.60E-03	1.5E+01	1.4E+03	1.4E+01	1.5E+01	1.6E-04	2.7E-04	2.7E-03
Chloroethane	0.0013	65	1.11E-02	1.7E+01	1.6E+03	1.6E+01	1.7E+01	4.6E-04	7.6E-04	7.7E-03
1,1-Dichloroethane	0.00086	99	4.31E-03	1.3E+01	1.3E+03	1.3E+01	1.3E+01	2.5E-04	4.1E-04	4.1E-03
1,2-Dichloroethane	0.00097	99	9.78E-04	1.3E+01	1.3E+03	1.1E+01	1.1E+01	2.4E-04	4.0E-04	4.0E-03
1,2-Dichloropropane	0.00027	113	2.10E-03	1.2E+01	1.2E+03	1.1E+01	1.2E+01	7.0E-05	1.2E-04	1.2E-03
1,2-Dichloroethene	0.0014	97	7.07E-03	1.3E+01	1.3E+03	1.3E+01	1.4E+01	4.1E-04	6.9E-04	6.9E-03

SHOWR-S4 | 13-Dec-93

TABLE L-2
CONCENTRATION OF VOLATILE COMPOUNDS RESULTING FROM SHOWERING
SHEPLEY'S HILL LANDFILL – WELL GROUP 4
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
EMPIRICAL CONSTANTS

CONSTANT	SYMBOL	VALUE	UNIT	SOURCE
Liquid–film mass transfer for CO2	kl (CO2)	20	cm/hr	Calculated
Gas–film mass transfer for H2O	kg (H2O)	3000	cm/hr	Calculated
Molar gas constant x Temperature	RT	0.024	atm–m^3/mole	Constant
Reference temperature	T1	293	°K	Constant
Temperature of shower water	Ts	318	°K	Assumption
Viscosity of water at shower temperature	μs	0.6178	cp	Calculated
Viscosity of water at reference temperature	$\mu 1$	0.65	cp	Calculated
Shower droplet free–fall time	ts	1.5	sec	Assumption
Droplet diameter	d	1	mm	Foster and Chrostowski, 1987
Flow rate in shower	FR	20	l/min	Assumption
Volume of shower area	SV	12	m^3	Assumption
Air exchange rate	R	0.03	min^{-1}	Calculated
Time in shower	Ds	12	min	USEPA, 1989f
Time at which concentration is being calculated	t	12	min	USEPA, 1989f

Foster, S.A. and Chrostowski, P.C., 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower
USEPA, 1989. Risk Assessment Guidance for Superfund

SHOWER CONCENTRATIONS

COMPOUND	Cwo (mg/l)	MW (g/mol)	H (atm–m^3/mol)	kl (cm/hr)	kg (cm/hr)	Kl (cm/hr)	Kal (cm/hr)	Cwd (mg/l)	S (mg/m^3–min)	Cvoc (mg/m^3)
MAXIMUM CONCENTRATIONS										
Trichlorofluoromethane	0.0021	137	1.26E–01	1.1E+01	1.1E+03	1.1E+01	1.2E+01	5.5E–04	9.1E–04	9.2E–03

HUMAN HEALTH RISK SPREADSHEETS

COLD SPRING BROOK LANDFILL

GCIGUMA | 15-Dec-93

TABLE M-1
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3 cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.

USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE M-1, continued
GROUNDWATER - INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE - UNFILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	0.014	1	3.3E-05	0.187	3.0E-04	0.014	0.014	4.6E-07	4.2E-06	4.6E-06
Arsenic	0.04	1	9.4E-05	0.0002	9.1E-07	1.75	1.79	1.6E-04	1.6E-06	1.7E-04
					SUMMARY CANCER RISK			**2E-04**	**6E-06**	**2E-04**

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE M-1, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Bis(2-ethylhexyl)phthalate	0.014	1	7.7E-05	0.187	7.0E-04	0.02	0.02	3.8E-03	3.5E-02	3.9E-02
Aluminum	20.5	1	1.1E-01	0.0002	1.1E-03	ND	ND	ND		
Arsenic	0.04	1	2.2E-04	0.0002	2.1E-06	0.0003	0.000294	7.3E-01	7.2E-03	7.4E-01
Barium	0.112	1	6.1E-04	0.0002	6.0E-06	0.07	0.0049	8.8E-03	1.2E-03	1.0E-02
Calcium	164	1	9.0E-01	0.0002	8.7E-03	ND	ND			
Chromium VI	0.0308	1	1.7E-04	0.0002	1.6E-06	0.005	0.00055	3.4E-02	3.0E-03	3.7E-02
Copper	0.031	1	1.7E-04	0.0002	1.6E-06	ND	ND			
Iron	25.4	1	1.4E-01	0.0002	1.4E-03	ND	ND			
Potassium	8.54	1	4.7E-02	0.0002	4.5E-04	ND	ND			
Magnesium	28.9	1	1.6E-01	0.0002	1.5E-03	ND	ND			
Manganese	5.7	1	3.1E-02	0.0002	3.0E-04	0.005	0.0002	6.2E+00	1.5E+00	7.8E+00
Sodium	42.9	1	2.4E-01	0.0002	2.3E-03	ND	ND	ND		
Nickel	0.049	1	2.7E-04	0.0002	2.6E-06	0.02	0.001	1.3E-02	2.6E-03	1.6E-02
Lead	0.0134	1	7.3E-05	0.0002	7.1E-07	ND	ND			
Vanadium	0.0263	1	1.4E-04	0.0002	1.4E-06	0.007	0.00021	2.1E-02	6.7E-03	2.7E-02
Zinc	0.0601	1	3.3E-04	0.0002	3.2E-06	0.3	0.102	1.1E-03	3.1E-05	1.1E-03
SUMMARY HAZARD INDEX								7E+00	2E+00	9E+00

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

GCIGUMC | 15-Dec-93

TABLE M-2
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE M-2, continued
GROUNDWATER - INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE - (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	0.014	1	6.0E-06	0.187	8.1E-05	0.014	0.014	8.4E-08	1.1E-06	1.2E-06
Arsenic	0.04	1	1.7E-05	0.0002	2.5E-07	1.75	1.79	3.0E-05	4.4E-07	3.0E-05
					SUMMARY CANCER RISK			3E-05	2E-06	3E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE M-2, continued
GROUNDWATER - INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE - (SUBCHRONIC) UNFILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Bis(2-ethylhexyl)phthalate	0.014	1	8.4E-05	0.187	1.1E-03	0.02	0.02	4.2E-03	5.6E-02	6.1E-02
Aluminum	20.5	1	1.2E-01	0.0002	1.8E-03	ND	ND			
Arsenic	0.04	1	2.4E-04	0.0002	3.4E-06	0.0003	0.000294	8.0E-01	1.2E-02	8.1E-01
Barium	0.112	1	6.7E-04	0.0002	9.7E-06	0.07	0.00493	9.6E-03	2.0E-03	1.2E-02
Calcium	164	1	9.8E-01	0.0002	1.4E-02	ND	ND			
Chromium VI	0.0308	1	1.8E-04	0.0002	2.7E-06	0.02	0.0022	9.2E-03	1.2E-03	1.0E-02
Copper	0.031	1	1.9E-04	0.0002	2.7E-06	ND	ND			
Iron	25.4	1	1.5E-01	0.0002	2.2E-03	ND	ND			
Potassium	8.54	1	5.1E-02	0.0002	7.4E-04	ND	ND			
Magnesium	28.9	1	1.7E-01	0.0002	2.5E-03	ND	ND			
Manganese	5.7	1	3.4E-02	0.0002	4.9E-04	0.005	0.0002	6.8E+00	2.5E+00	9.3E+00
Sodium	42.9	1	2.6E-01	0.0002	3.7E-03	ND	ND			
Nickel	0.049	1	2.9E-04	0.0002	4.2E-06	0.02	0.001	1.5E-02	4.2E-03	1.9E-02
Lead	0.0134	1	8.0E-05	0.0002	1.2E-06	ND	ND			
Vanadium	0.0263	1	1.6E-04	0.0002	2.3E-06	0.007	0.00021	2.3E-02	1.1E-02	3.3E-02
Zinc	0.0601	1	3.6E-04	0.0002	5.2E-06	0.3	0.102	1.2E-03	5.1E-05	1.3E-03
					SUMMARY HAZARD INDEX			8E+00	3E+00	1E+01

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

GCIGUAA | 15-Dec-93

TABLE M-3
GROUNDWATER - INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE - UNFILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365 \text{ days/yr}}$$

Where:

$DA_{event} = PC_{event} \times CW$

Note:

For noncarcinogenic effects: AT = ED

Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE M-3, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	0.004	1	9.4E-06	0.187	8.5E-05	0.014	0.014	1.3E-07	1.2E-06	1.3E-06
Arsenic	0.014	1	3.3E-05	0.0002	3.2E-07	1.75	1.79	5.8E-05	5.7E-07	5.8E-05
SUMMARY CANCER RISK								6E-05	2E-06	6E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE M-3, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – UNFILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Bis(2-ethylhexyl)phthalate	0.004	1	2.2E-05	0.187	2.0E-04	0.02	0.02	1.1E-03	9.9E-03	1.1E-02
Aluminum	3.9	1	2.1E-02	0.0002	2.1E-04	ND	ND			
Arsenic	0.014	1	7.7E-05	0.0002	7.4E-07	0.0003	0.000294	2.6E-01	2.5E-03	2.6E-01
Barium	0.041	1	2.2E-04	0.0002	2.2E-06	0.07	0.0049	3.2E-03	4.4E-04	3.7E-03
Calcium	69.3	1	3.8E-01	0.0002	3.7E-03	ND	ND			
Chromium VI	0.008	1	4.4E-05	0.0002	4.3E-07	0.005	0.00055	8.8E-03	7.7E-04	9.5E-03
Copper	0.011	1	6.0E-05	0.0002	5.8E-07	ND	ND			
Iron	9.6	1	5.3E-02	0.0002	5.1E-04	ND	ND			
Potassium	5.6	1	3.1E-02	0.0002	3.0E-04	ND	ND			
Magnesium	12.3	1	6.7E-02	0.0002	6.5E-04	ND	ND			
Manganese	2.5	1	1.4E-02	0.0002	1.3E-04	0.005	0.0002	2.7E+00	6.6E-01	3.4E+00
Sodium	18.1	1	9.9E-02	0.0002	9.6E-04	ND	ND			
Nickel	0.021	1	1.2E-04	0.0002	1.1E-06	0.02	0.001	5.8E-03	1.1E-03	6.9E-03
Lead	0.0041	1	2.2E-05	0.0002	2.2E-07	ND	ND			
Vanadium	0.0081	1	4.4E-05	0.0002	4.3E-07	0.007	0.00021	6.3E-03	2.1E-03	8.4E-03
Zinc	0.02	1	1.1E-04	0.0002	1.1E-06	0.3	0.102	3.7E-04	1.0E-05	3.8E-04
					SUMMARY HAZARD INDEX			**3E+00**	**7E-01**	**4E+00**

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE M-4
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/$10^3 cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE M-4, continued
GROUNDWATER - INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE - (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	0.004	1	1.7E-06	0.187	2.3E-05	0.014	0.014	2.4E-08	3.2E-07	3.5E-07
Arsenic	0.014	1	6.0E-06	0.0002	8.6E-08	1.75	1.79	1.0E-05	1.5E-07	1.1E-05
					SUMMARY CANCER RISK			**1E-05**	**5E-07**	**1E-05**

[1] Calculated from Oral CSF as described in section 6.1.2.3.

TABLE M-4, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) UNFILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Bis(2-ethylhexyl)phthalate	0.004	1	2.4E-05	0.187	3.2E-04	0.02	0.02	1.2E-03	1.6E-02	1.7E-02
Aluminum	3.9	1	2.3E-02	0.0002	3.4E-04	ND	ND			
Arsenic	0.014	1	8.4E-05	0.0002	1.2E-06	0.0003	0.000294	2.8E-01	4.1E-03	2.8E-01
Barium	0.041	1	2.5E-04	0.0002	3.5E-06	0.07	0.00493	3.5E-03	7.2E-04	4.2E-03
Calcium	69.3	1	4.2E-01	0.0002	6.0E-03	ND	ND			
Chromium VI	0.008	1	4.8E-05	0.0002	6.9E-07	0.02	0.0022	2.4E-03	3.1E-04	2.7E-03
Copper	0.011	1	6.6E-05	0.0002	9.5E-07	ND	ND			
Iron	9.6	1	5.8E-02	0.0002	8.3E-04	ND	ND			
Potassium	5.6	1	3.4E-02	0.0002	4.8E-04	ND	ND			
Magnesium	12.3	1	7.4E-02	0.0002	1.1E-03	ND	ND			
Manganese	2.5	1	1.5E-02	0.0002	2.2E-04	0.005	0.0002	3.0E+00	1.1E+00	4.1E+00
Sodium	18.1	1	1.1E-01	0.0002	1.6E-03	ND	ND			
Nickel	0.021	1	1.3E-04	0.0002	1.8E-06	0.02	0.001	6.3E-03	1.8E-03	8.1E-03
Lead	0.0041	1	2.5E-05	0.0002	3.5E-07	ND	ND			
Vanadium	0.0081	1	4.9E-05	0.0002	7.0E-07	0.007	0.00021	6.9E-03	3.3E-03	1.0E-02
Zinc	0.02	1	1.2E-04	0.0002	1.7E-06	0.3	0.102	4.0E-04	1.7E-05	4.2E-04
					SUMMARY HAZARD INDEX			3E+00	1E+00	4E+00

ND = No data available
[1] Calculated from Oral RfD as described in section 6.1.2.3.

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TABLE M-5
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3 cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE M-5, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.02	1	4.7E-05	0.0002	4.6E-07	1.75	1.79	8.2E-05	8.2E-07	8.3E-05
					SUMMARY CANCER RISK			8E-05	8E-07	8E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE M-5, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.02	1	1.1E-04	0.0002	1.1E-06	0.0003	0.000294	3.7E-01	3.6E-03	3.7E-01
Calcium	148	1	8.1E-01	0.0002	7.9E-03	ND	ND			
Iron	14.6	1	8.0E-02	0.0002	7.8E-04	ND	ND			
Magnesium	25	1	1.4E-01	0.0002	1.3E-03	ND	ND			
Manganese	6.12	1	3.4E-02	0.0002	3.3E-04	0.005	0.0002	6.7E+00	1.6E+00	8.3E+00
Potassium	17	1	9.3E-02	0.0002	9.0E-04	ND	ND			
Sodium	18.6	1	1.0E-01	0.0002	9.9E-04	ND	ND			
Vanadium	0.012	1	6.6E-05	0.0002	6.4E-07	0.007	0.00021	9.4E-03	3.0E-03	1.2E-02
					SUMMARY HAZARD INDEX			7E+00	2E+00	9E+00

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE M-6
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	liter/10^3cm^3	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE M-6, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.02	1	8.6E-06	0.0002	1.2E-07	1.75	1.79	1.5E-05	2.2E-07	1.5E-05
					SUMMARY CANCER RISK			1E-05	2E-07	2E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE M-6, continued
GROUNDWATER - INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE - (SUBCHRONIC) FILTERED, MAXIMUM CONCENTRATION
COLD SPRING BROOK LANDFILL
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.02	1	1.2E-04	0.0002	1.7E-06	0.0003	0.000294	4.0E-01	5.9E-03	4.1E-01
Calcium	148	1	8.9E-01	0.0002	1.3E-02	ND	ND			
Iron	14.6	1	8.8E-02	0.0002	1.3E-03	ND	ND			
Magnesium	25	1	1.5E-01	0.0002	2.2E-03	ND	ND			
Manganese	6.12	1	3.7E-02	0.0002	5.3E-04	0.005	0.0002	7.3E+00	2.6E+00	1.0E+01
Potassium	17	1	1.0E-01	0.0002	1.5E-03	ND	ND			
Sodium	18.6	1	1.1E-01	0.0002	1.6E-03	ND	ND			
Vanadium	0.012	1	7.2E-05	0.0002	1.0E-06	0.007	0.00021	1.0E-02	4.9E-03	1.5E-02
					SUMMARY HAZARD INDEX			8E+00	3E+00	1E+01

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE M-7
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
COLD SPRING BROOK LANDFILL
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE'	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	2	liters/day	USEPA, 1991b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	70	kg	USEPA, 1991b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [1] (USEPA, 1992d)
SHOWER EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1989f
SURFACE AREA EXPOSED	SA	19400.0	cm^2	USEPA, 1989b [2]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] PC_{event} calculated in Appendix W
[2] Surface Area represents entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times ED \times CF \times SA}{BW \times AT \times 365 \text{ days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption Factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

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TABLE M-7, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0049	1	1.2E-05	0.0002	1.1E-07	1.75	1.79	2.0E-05	2.0E-07	2.0E-05
					SUMMARY CANCER RISK			2E-05	2E-07	2E-05

[1] Calculated from Oral CSF as described in Section 6.1.2.3.

TABLE M-7, continued
GROUNDWATER – INGESTION AND CONTACT DURING SHOWERING
ADULT EXPOSURE – FILTERED, AVERAGE CONCENTRATION
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.0049	1	2.7E-05	0.0002	2.6E-07	0.0003	0.000294	8.9E-02	8.9E-04	9.0E-02
Calcium	64.5	1	3.5E-01	0.0002	3.4E-03	ND	ND			
Iron	3.2	1	1.8E-02	0.0002	1.7E-04	ND	ND			
Magnesium	11.5	1	6.3E-02	0.0002	6.1E-04	ND	ND			
Manganese	3	1	1.6E-02	0.0002	1.6E-04	0.005	0.0002	3.3E+00	8.0E-01	4.1E+00
Potassium	5.9	1	3.2E-02	0.0002	3.1E-04	ND	ND			
Sodium	13.2	1	7.2E-02	0.0002	7.0E-04	ND	ND			
Vanadium	0.0076	1	4.2E-05	0.0002	4.0E-07	ND	0.00021	5.9E-03	1.9E-03	7.9E-03
SUMMARY HAZARD INDEX								3E+00	8E-01	4E+00

ND = No data available
[1] Calculated from Oral RfD as described in Section 6.1.2.3.

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TABLE M-8
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, AVERAGE CONCENTRATION
COLD SPRING BROOK LANDFILL
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical specific	mg/liter	
INGESTION RATE	IR	0.5	liters/day	USEPA, 1989b
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm^3	USEPA, 1989b
EVENT FREQUENCY	EV	1	events/day	
BODY WEIGHT	BW	16	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm^2-event	Calculated [2] (USEPA, 1992d)
BATH EXPOSURE TIME	ET	0.2	hours/day	USEPA, 1989f
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	Assumption
AGE-SPECIFIC EXPSOURE DURATION	ED_i	age-specific	years	USEPA, 1989b
AGE-WEIGHTED SURFACE AREA [1]	SA_{adj}	2247.5	cm^2-yr/kg	Appendix V [3](USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f
CONVERSION FACTOR	CF	0.001	$liter/10^3cm^3$	

[1] The calculations for normalized surface area (SA_{adj}) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
[2] PC_{event} calculated in Appendix W.
[3] Surface area represents the entire body.
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989f. Risk Assessment Guidance for Superfund.
USEPA, 1991b. Standard Default Exposure Factors.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times ABS_i \times ET \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DA_{event} \times EV \times EF \times CF \times SA_{adj}}{AT \times 365\ \text{days/yr}}$$

Where:
$DA_{event} = PC_{event} \times CW$

Note:
For noncarcinogenic effects: AT = ED
Absorption factors (ABS_i) for ingestion are set equal to one (USEPA Region I default value).

TABLE M-8, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, AVERAGE CONCENTRATION
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CARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	DERMAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	0.0049	1	2.1E-06	0.0002	3.0E-08	1.75	1.79	3.7E-06	5.4E-08	3.7E-06
					SUMMARY CANCER RISK			4E-06	5E-08	4E-06

[1] Calculated from Oral CSF as dsecribed in Section 6.1.2.3.

TABLE M-8, continued
GROUNDWATER – INGESTION AND CONTACT DURING BATHING
CHILD EXPOSURE – (SUBCHRONIC) FILTERED, AVERAGE CONCENTRATION
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NONCARCINOGENIC EFFECTS

COMPOUND	WATER CONCENTRATION (mg/l)	INGESTION ABS_i	INTAKE INGESTION (mg/kg-day)	PC_{EVENT} (cm/event)	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	DERMAL RfD [1] (mg/kg-day)^-1	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	0.0049	1	2.9E-05	0.0002	4.2E-07	0.0003	0.000294	9.8E-02	1.4E-03	9.9E-02
Calcium	64.5	1	3.9E-01	0.0002	5.6E-03	ND	ND			
Iron	3.2	1	1.9E-02	0.0002	2.8E-04	ND	ND			
Magnesium	11.5	1	6.9E-02	0.0002	9.9E-04	ND	ND			
Manganese	3	1	1.8E-02	0.0002	2.6E-04	0.005	0.0002	3.6E+00	1.3E+00	4.9E+00
Potassium	5.9	1	3.5E-02	0.0002	5.1E-04	ND	ND			
Sodium	13.2	1	7.9E-02	0.0002	1.1E-03	ND	ND			
Vanadium	0.0076	1	4.6E-05	0.0002	6.6E-07	0.007	0.00021	6.5E-03	3.1E-03	9.6E-03
SUMMARY HAZARD INDEX								4E+00	1E+00	5E+00

ND = No data available
[1] Calculated from Oral RfD as dsecribed in Section 6.1.2.3.

TABLE M-9
FISH INGESTION – COLD SPRING BROOK POND – WHOLE FISH (PUMPKINSEEDS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
CURRENT AND FUTURE LAND USE
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	54	g/day	USEPA, 1991b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.05		ASSUMPTION
BODY WEIGHT	BW	70	kg	USEPA, 1991b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f

USEPA, 1991b "STANDARD DEFAULT EXPOSURE FACTORS"
USEPA, 1989f "RISK ASSESSMENT GUIDANCE FOR SUPERFUND"

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE M-9, continued
FISH INGESTION - COLD SPRING BROOK POND - WHOLE FISH (PUMPKINSEEDS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.15	0.27	2.4E-06	4.3E-06	1.75	4.2E-06	7.5E-06
P,P-DDE	0.083	0.17	1.3E-06	2.7E-06	0.34	4.5E-07	9.2E-07
P,P-DDD	0.12	0.23	1.9E-06	3.6E-06	0.24	4.6E-07	8.7E-07
SUMMARY CANCER RISK						5E-06	9E-06

TABLE M-9, continued
FISH INGESTION - COLD SPRING BROOK POND - WHOLE FISH (PUMPKINSEEDS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.15	0.27	5.5E-06	1.0E-05	0.0003	1.8E-02	3.3E-02
P,P-DDE	0.083	0.17	3.1E-06	6.3E-06	0.0005	6.1E-03	1.3E-02
P,P-DDD	0.12	0.23	4.4E-06	8.5E-06	0.0005	8.9E-03	1.7E-02
Manganese	10	12	3.7E-04	4.4E-04	0.14	2.6E-03	3.2E-03
Zinc	21	24.1	7.8E-04	8.9E-04	0.3	2.6E-03	3.0E-03
Barium	0.47	0.64	1.7E-05	2.4E-05	0.07	2.5E-04	3.4E-04
Calcium	13137	15500	4.9E-01	5.7E-01	ND		
Chromium III	0.3	0.33	1.1E-05	1.2E-05	1	1.1E-05	1.2E-05
Cobalt	0.12	0.2	4.4E-06	7.4E-06	ND		
Copper	0.39	0.41	1.4E-05	1.5E-05	ND		
Iron	32.9	41.5	1.2E-03	1.5E-03	ND		
Mercury	0.16	0.24	5.9E-06	8.9E-06	0.0003	2.0E-02	3.0E-02
Selenium	0.25	0.45	9.2E-06	1.7E-05	0.005	1.8E-03	3.3E-03
Sodium	1173	1280	4.3E-02	4.7E-02	ND		
Magnesium	417	464	1.5E-02	1.7E-02	ND		
					SUMMARY HAZARD INDEX	6E-02	1E-01

ND = No data available

TABLE M-10

FISH INGESTION – COLD SPRING BROOK POND – WHOLE FISH (PUMPKINSEEDS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
CURRENT AND FUTURE LAND USE
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	16.5	g/day	USEPA, 1989b
RELATIVE ABSORPTION	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.05		ASSUMPTION
BODY WEIGHT	BW	16	kg	USEPA, 1989b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	ASSUMPTION
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f

USEPA, 1991b "STANDARD DEFAULT EXPOSURE FACTORS"
USEPA, 1989b "EXPOSURE FACTORS HANDBOOK"
USEPA, 1989f "RISK ASSESSMENT GUIDANCE FOR SUPERFUND"

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CF x IR x RAF x FI x C x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE M-10, continued

FISH INGESTION – COLD SPRING BROOK POND – WHOLE FISH (PUMPKINSEEDS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.15	0.27	5.3E-07	9.5E-07	1.75	9.3E-07	1.7E-06
P,P-DDE	0.083	0.17	2.9E-07	6.0E-07	0.34	1.0E-07	2.0E-07
P,P-DDD	0.12	0.23	4.2E-07	8.1E-07	0.24	1.0E-07	1.9E-07
SUMMARY CANCER RISK						1E-06	2E-06

TABLE M-10, continued
FISH INGESTION – COLD SPRING BROOK POND – WHOLE FISH (PUMPKINSEEDS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.15	0.27	7.4E-06	1.3E-05	0.0003	2.5E-02	4.4E-02
P,P-DDE	0.083	0.17	4.1E-06	8.4E-06	0.0005	8.2E-03	1.7E-02
P,P-DDD	0.12	0.23	5.9E-06	1.1E-05	0.0005	1.2E-02	2.3E-02
Manganese	10	12	4.9E-04	5.9E-04	0.14	3.5E-03	4.2E-03
Zinc	21	24.1	1.0E-03	1.2E-03	0.3	3.5E-03	4.0E-03
Barium	0.47	0.64	2.3E-05	3.2E-05	0.07	3.3E-04	4.5E-04
Calcium	13137	15500	6.5E-01	7.7E-01	ND		
Chromium III	0.3	0.33	1.5E-05	1.6E-05	1	1.5E-05	1.6E-05
Cobalt	0.12	0.2	5.9E-06	9.9E-06	ND		
Copper	0.39	0.41	1.9E-05	2.0E-05	ND		
Iron	32.9	41.5	1.6E-03	2.1E-03	ND		
Mercury	0.16	0.24	7.9E-06	1.2E-05	0.0003	2.6E-02	4.0E-02
Selenium	0.25	0.45	1.2E-05	2.2E-05	0.005	2.5E-03	4.4E-03
Sodium	1173	1280	5.8E-02	6.3E-02	ND		
Magnesium	417	464	2.1E-02	2.3E-02	ND		
				SUMMARY HAZARD INDEX		8E-02	1E-01

ND = No data available

TABLE M-11
FISH INGESTION – COLD SPRING BROOK POND – FILLETS (BULLHEADS, PICKERELS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
CURRENT AND FUTURE LAND USE
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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	54	g/day	USEPA, 1991b
RELATIVE ABSORPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.05		ASSUMPTION
BODY WEIGHT	BW	70	kg	USEPA, 1991b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	30	years	USEPA, 1991b
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	30	years	USEPA, 1989f

USEPA, 1991b "STANDARD DEFAULT EXPOSURE FACTORS"
USEPA, 1989f "RISK ASSESSMENT GUIDANCE FOR SUPERFUND"

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE M-11, continued
FISH INGESTION – COLD SPRING BROOK POND – FILLETS (BULLHEADS, PICKERELS)
ADULT EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.2	0.32	3.2E-06	5.1E-06	1.75	5.5E-06	8.9E-06
P,P-DDE	0.012	0.021	1.9E-07	3.3E-07	0.34	6.5E-08	1.1E-07
P,P-DDD	0.019	0.05	3.0E-07	7.9E-07	0.24	7.2E-08	1.9E-07
SUMMARY CANCER RISK						6E-06	9E-06

TABLE M-11, continued

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FISH INGESTION - COLD SPRING BROOK POND - FILLETS (BULLHEADS, PICKERELS)
ADULT EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
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NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.2	0.32	7.4E-06	1.2E-05	0.0003	2.5E-02	3.9E-02
P,P-DDE	0.012	0.021	4.4E-07	7.8E-07	0.0005	8.9E-04	1.6E-03
P,P-DDD	0.019	0.05	7.0E-07	1.8E-06	0.0005	1.4E-03	3.7E-03
Manganese	0.37	1	1.4E-05	3.7E-05	0.14	9.8E-05	2.6E-04
Zinc	5.45	6.5	2.0E-04	2.4E-04	0.3	6.7E-04	8.0E-04
Calcium	217	505	8.0E-03	1.9E-02	ND		
Copper	0.3	0.35	1.1E-05	1.3E-05	ND		
Iron	6.11	9.1	2.3E-04	3.4E-04	ND		
Mercury	0.31	0.46	1.1E-05	1.7E-05	0.0003	3.8E-02	5.7E-02
Selenium	0.18	0.24	6.7E-06	8.9E-06	0.005	1.3E-03	1.8E-03
Sodium	385	455	1.4E-02	1.7E-02	ND		
Magnesium	269	329	9.9E-03	1.2E-02	ND		
					SUMMARY HAZARD INDEX	7E-02	1E-01

ND = No data available

TABLE M-12
FISH INGESTION – COLD SPRING BROOK POND – FILLETS (BULLHEADS, PICKERELS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
CURRENT AND FUTURE LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

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EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION IN FISH	CF		mg/kg	SITE-SPECIFIC
FISH INGESTION RATE	IR	16.5	g/day	USEPA, 1989b
RELATIVE ABSROPTION FACTOR	RAF	1		ASSUMPTION
FRACTION INGESTED FROM SOURCE	FI	0.05		ASSUMPTION
BODY WEIGHT	BW	16	kg	USEPA, 1989b
CONVERSION FACTOR	C	0.001	kg/g	
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1991b
EXPOSURE DURATION	ED	5	years	ASSUMPTION
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	5	years	USEPA, 1989f

USEPA, 1991b "STANDARD DEFAULT EXPOSURE FACTORS"
USEPA, 1989b "EXPOSURE FACTORS HANDBOOK"
USEPA, 1989f "RISK ASSESSMENT GUIDANCE FOR SUPERFUND"

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CF \times IR \times RAF \times FI \times C \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

Note:
For noncarcinogenic effects: AT = ED

TABLE M-12, continued

FISH INGESTION – COLD SPRING BROOK POND – FILLETS (BULLHEADS, PICKERELS)
CHILD EXPOSURE – AVERAGE AND MAXIMUM CONCENTRATIONS
CURRENT AND FUTURE LAND USE
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CARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	TOTAL CANCER RISK AVG. CONC.	TOTAL CANCER RISK MAX. CONC.
Arsenic	0.2	0.32	7.1E-07	1.1E-06	1.75	1.2E-06	2.0E-06
P,P-DDE	0.012	0.021	4.2E-08	7.4E-08	0.34	1.4E-08	2.5E-08
P,P-DDD	0.019	0.05	6.7E-08	1.8E-07	0.24	1.6E-08	4.2E-08
				SUMMARY CANCER RISK		1E-06	2E-06

TABLE M-12, continued
FISH INGESTION - COLD SPRING BROOK POND - FILLETS (BULLHEADS, PICKERELS)
CHILD EXPOSURE - AVERAGE AND MAXIMUM CONCENTRATIONS
CURRENT AND FUTURE LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
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FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	AVERAGE CONCENTRATION IN FISH (mg/kg)	MAXIMUM CONCENTRATION IN FISH (mg/kg)	INTAKE AVG. CONC. (mg/kg-day)	INTAKE MAX. CONC. (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	TOTAL HAZARD QUOTIENT AVG. CONC.	TOTAL HAZARD QUOTIENT MAX. CONC.
Arsenic	0.2	0.32	9.9E-06	1.6E-05	0.0003	3.3E-02	5.3E-02
P,P-DDE	0.012	0.021	5.9E-07	1.0E-06	0.0005	1.2E-03	2.1E-03
P,P-DDD	0.019	0.05	9.4E-07	2.5E-06	0.0005	1.9E-03	4.9E-03
Manganese	0.37	1	1.8E-05	4.9E-05	0.14	1.3E-04	3.5E-04
Zinc	5.45	6.5	2.7E-04	3.2E-04	0.3	9.0E-04	1.1E-03
Calcium	217	505	1.1E-02	2.5E-02	ND		
Copper	0.3	0.35	1.5E-05	1.7E-05	ND		
Iron	6.11	9.1	3.0E-04	4.5E-04	ND		
Mercury	0.31	0.46	1.5E-05	2.3E-05	0.0003	5.1E-02	7.6E-02
Selenium	0.18	0.24	8.9E-06	1.2E-05	0.005	1.8E-03	2.4E-03
Sodium	385	455	1.9E-02	2.2E-02	ND		
Magnesium	269	329	1.3E-02	1.6E-02	ND		
				SUMMARY HAZARD INDEX		9E-02	1E-01

ND = No data available

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TABLE M-13
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - AVERAGE EXPOSURE
CURRENT LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	5	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.

[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

USEPA, 1991b. "Standard Default Exposure Factors".

USEPA, 1989b. Exposure Factors Handbook.

USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.

USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365 \text{ days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM(SA_i \times ED_i / BW_i)$$

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE M-13, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - AVERAGE EXPOSURE
CURRENT LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
CARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
P,P-DDE	0.09	0.3	1.3E-10	0.05	3.7E-10	3.40E-01	4.3E-11	1.7E+00	6.4E-10	6.8E-10
Benzo(a)anthracene	0.51	1	2.4E-09	0.05	2.1E-09	7.30E+00	1.7E-08	8.0E+00	1.7E-08	3.4E-08
Chrysene	0.63	1	2.9E-09	0.05	2.6E-09	7.30E+00	2.1E-08	8.0E+00	2.1E-08	4.2E-08
Arsenic	78	1	3.6E-07	0.01	6.5E-08	1.75E+00	6.4E-07	1.8E+00	1.2E-07	7.5E-07
Beryllium	0.19	1	8.9E-10	0.01	1.6E-10	4.30E+00	3.8E-09	4.3E+02	6.8E-08	7.2E-08
P,P-DDD	0.5	0.3	7.0E-10	0.05	2.1E-09	2.40E-01	1.7E-10	1.2E+00	2.5E-09	2.7E-09
Bis(2-ethylhexyl)phthalate	1.4	1	6.5E-09	0.5	5.8E-08	1.40E-02	9.1E-11	1.4E-02	8.1E-10	9.1E-10
Benzo(a)pyrene	1.1	1	5.1E-09	0.05	4.6E-09	7.30E+00	3.7E-08	8.0E+00	3.7E-08	7.4E-08
Benzo(b)fluoranthene	0.64	1	3.0E-09	0.05	2.7E-09	7.30E+00	2.2E-08	8.0E+00	2.1E-08	4.3E-08
Benzo(k)fluoranthene	0.9	1	4.2E-09	0.05	3.7E-09	7.30E+00	3.1E-08	8.0E+00	3.0E-08	6.1E-08
Indeno(1,2,3-cd)pyrene	0.56	1	2.6E-09	0.05	2.3E-09	7.30E+00	1.9E-08	8.0E+00	1.9E-08	3.8E-08
P,P-DDT	0.64	0.3	8.9E-10	0.05	2.7E-09	3.40E-01	3.0E-10	1.7E+00	4.5E-09	4.8E-09
					SUMMARY CANCER RISK		**8E-07**		**3E-07**	**1E-06**

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE M-13, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - AVERAGE EXPOSURE
CURRENT LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
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NONCARCINOGENIC EFFECTS

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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
P,P-DDE	0.09	0.3	8.8E-10	0.05	2.6E-09	0.0005	1.8E-06	0.0001	2.6E-05	2.8E-05
Benzo(a)anthracene	0.51	1	1.7E-08	0.05	1.5E-08	0.04	4.2E-07	0.04	3.7E-07	7.9E-07
Chrysene	0.63	1	2.1E-08	0.05	1.8E-08	0.04	5.1E-07	0.04	4.6E-07	9.7E-07
Arsenic	78	1	2.5E-06	0.01	4.5E-07	0.0003	8.5E-03	0.000294	1.5E-03	1.0E-02
Fluoranthene	1.6	1	5.2E-08	0.05	4.6E-08	0.04	1.3E-06	0.0364	1.3E-06	2.6E-06
Phenanthrene	0.77	1	2.5E-08	0.05	2.2E-08	0.04	6.3E-07	0.04	5.6E-07	1.2E-06
Pyrene	2.2	1	7.2E-08	0.05	6.4E-08	0.03	2.4E-06	0.0273	2.3E-06	4.7E-06
Barium	36.8	1	1.2E-06	0.01	2.1E-07	0.07	1.7E-05	0.0049	4.4E-05	6.1E-05
Manganese	634	1	2.1E-05	0.01	3.7E-06	0.14	1.5E-04	0.0056	6.6E-04	8.1E-04
Nickel	10.8	1	3.5E-07	0.01	6.3E-08	0.02	1.8E-05	0.001	6.3E-05	8.0E-05
Beryllium	0.19	1	6.2E-09	0.01	1.1E-09	0.005	1.2E-06	0.00005	2.2E-05	2.3E-05
Aluminum	6108	1	2.0E-04	0.01	3.6E-05	ND		ND		
Chromium VI	1.51	1	4.9E-08	0.01	8.8E-09	0.005	9.8E-06	0.00055	1.6E-05	2.6E-05
Chromium III	13.59	1	4.4E-07	0.01	7.9E-08	1	4.4E-07	0.1	7.9E-07	1.2E-06
Copper	8.5	1	2.8E-07	0.01	4.9E-08	ND		ND		
Vanadium	12.1	1	3.9E-07	0.01	7.0E-08	0.007	5.6E-05	0.00021	3.3E-04	3.9E-04
Zinc	82.3	1	2.7E-06	0.01	4.8E-07	0.3	8.9E-06	0.102	4.7E-06	1.4E-05
Mercury	0.077	1	2.5E-09	0.01	4.5E-10	0.0003	8.4E-06	0.00006	7.5E-06	1.6E-05
Lead	69.5	0.3	6.8E-07	0.01	4.0E-07	ND		ND		
P,P-DDD	0.5	0.3	4.9E-09	0.05	1.5E-08	0.0005	9.8E-06	0.0001	1.5E-04	1.6E-04
Bis(2-ethylhexyl)phthalate	1.4	1	4.6E-08	0.5	4.1E-07	0.02	2.3E-06	0.02	2.0E-05	2.3E-05
Benzo(a)pyrene	1.1	1	3.6E-08	0.05	3.2E-08	0.04	9.0E-07	0.04	8.0E-07	1.7E-06
Benzo(b)fluoranthene	0.64	1	2.1E-08	0.05	1.9E-08	0.04	5.2E-07	0.04	4.6E-07	9.9E-07
Benzo(k)fluoranthene	0.9	1	2.9E-08	0.05	2.6E-08	0.04	7.3E-07	0.04	6.5E-07	1.4E-06
Indeno(1,2,3-cd)pyrene	0.56	1	1.8E-08	0.05	1.6E-08	0.04	4.6E-07	0.04	4.1E-07	8.6E-07

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE M-13, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - AVERAGE EXPOSURE
CURRENT LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Acenaphthylene	0.26	1	8.5E-09	0.05	7.6E-09	0.04	2.1E-07	0.04	1.9E-07	4.0E-07
Anthracene	0.27	1	8.8E-09	0.05	7.8E-09	0.3	2.9E-08	0.273	2.9E-08	5.8E-08
Benzo(g,h,i)perylene	0.48	1	1.6E-08	0.05	1.4E-08	0.04	3.9E-07	0.04	3.5E-07	7.4E-07
Calcium	8582	1	2.8E-04	0.01	5.0E-05	ND		ND		
Iron	15232	1	5.0E-04	0.01	8.9E-05	ND		ND		
Potassium	758	1	2.5E-05	0.01	4.4E-06	ND		ND		
Magnesium	2246	1	7.3E-05	0.01	1.3E-05	ND		ND		
Sodium	452	1	1.5E-05	0.01	2.6E-06	ND		ND		
P,P-DDT	0.64	0.3	6.3E-09	0.05	1.9E-08	0.0005	1.3E-05	0.0001	1.9E-04	2.0E-04
Acenaphthene	0.18	1	5.9E-09	0.05	5.2E-09	0.06	9.8E-08	0.0546	9.6E-08	1.9E-07
Dibenzofuran	0.15	1	4.9E-09	0.05	4.4E-09	ND		ND		
Fluorene	0.16	1	5.2E-09	0.05	4.6E-09	0.04	1.3E-07	0.04	1.2E-07	2.5E-07
Naphthalene	0.14	1	4.6E-09	0.05	4.1E-09	0.04	1.1E-07	0.04	1.0E-07	2.2E-07
Cobalt	3.38	1	1.1E-07	0.01	2.0E-08	ND		ND		
Selenium	1.96	1	6.4E-08	0.01	1.1E-08	0.005	1.3E-05	0.003	3.8E-06	1.7E-05
Silver	0.65	1	2.1E-08	0.01	3.8E-09	0.005	4.2E-06	0.00105	3.6E-06	7.8E-06
					SUMMARY HAZARD INDEX		9E-03		3E-03	1E-02

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

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TABLE M-14
SEDIMENT INGESTION AND CONTACT -- ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - MAXIMUM EXPOSURE
CURRENT LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	5	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365\ \text{days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM(SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE M-14, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - MAXIMUM EXPOSURE
CURRENT LAND USE
REMEDIAL INVESTIGATION ADDENDUM REPORT
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
P,P-DDE	0.72	0.3	1.0E-09	0.05	3.0E-09	3.40E-01	3.4E-10	1.7E+00	5.1E-09	5.4E-09
Benzo(a)anthracene	4	1	1.9E-08	0.05	1.7E-08	7.30E+00	1.4E-07	8.0E+00	1.3E-07	2.7E-07
Chrysene	8	1	3.7E-08	0.05	3.3E-08	7.30E+00	2.7E-07	8.0E+00	2.7E-07	5.4E-07
Arsenic	390	1	1.8E-06	0.01	3.2E-07	1.75E+00	3.2E-06	1.8E+00	5.8E-07	3.8E-06
Beryllium	0.41	1	1.9E-09	0.01	3.4E-10	4.30E+00	8.2E-09	4.3E+02	1.5E-07	1.5E-07
P,P-DDD	6.2	0.3	8.7E-09	0.05	2.6E-08	2.40E-01	2.1E-09	1.2E+00	3.1E-08	3.3E-08
Bis(2-ethylhexyl)phthalate	2	1	9.3E-09	0.5	8.3E-08	1.40E-02	1.3E-10	1.4E-02	1.2E-09	1.3E-09
Benzo(a)pyrene	6	1	2.8E-08	0.05	2.5E-08	7.30E+00	2.0E-07	8.0E+00	2.0E-07	4.0E-07
Benzo(b)fluoranthene	5	1	2.3E-08	0.05	2.1E-08	7.30E+00	1.7E-07	8.0E+00	1.7E-07	3.4E-07
Benzo(k)fluoranthene	10	1	4.7E-08	0.05	4.2E-08	7.30E+00	3.4E-07	8.0E+00	3.3E-07	6.7E-07
Indeno(1,2,3-cd)pyrene	2	1	9.3E-09	0.05	8.3E-09	7.30E+00	6.8E-08	8.0E+00	6.7E-08	1.3E-07
P,P-DDT	15	0.3	2.1E-08	0.05	6.2E-08	3.40E-01	7.1E-09	1.7E+00	1.1E-07	1.1E-07
					SUMMARY CANCER RISK		4E-06		2E-06	6E-06

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE M-14, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND – MAXIMUM EXPOSURE
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FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
P,P-DDE	0.72	0.3	7.0E-09	0.05	2.1E-08	0.0005	1.4E-05	0.0001	2.1E-04	2.2E-04
Benzo(a)anthracene	4	1	1.3E-07	0.05	1.2E-07	0.04	3.3E-06	0.04	2.9E-06	6.2E-06
Chrysene	8	1	2.6E-07	0.05	2.3E-07	0.04	6.5E-06	0.04	5.8E-06	1.2E-05
Arsenic	390	1	1.3E-05	0.01	2.3E-06	0.0003	4.2E-02	0.000294	7.7E-03	5.0E-02
Fluoranthene	10	1	3.3E-07	0.05	2.9E-07	0.04	8.2E-06	0.0364	8.0E-06	1.6E-05
Phenanthrene	6	1	2.0E-07	0.05	1.7E-07	0.04	4.9E-06	0.04	4.4E-06	9.3E-06
Pyrene	20	1	6.5E-07	0.05	5.8E-07	0.03	2.2E-05	0.0273	2.1E-05	4.3E-05
Barium	115	1	3.8E-06	0.01	6.7E-07	0.07	5.4E-05	0.0049	1.4E-04	1.9E-04
Manganese	3000	1	9.8E-05	0.01	1.7E-05	0.14	7.0E-04	0.0056	3.1E-03	3.8E-03
Nickel	54.3	1	1.8E-06	0.01	3.2E-07	0.02	8.9E-05	0.001	3.2E-04	4.0E-04
Beryllium	0.41	1	1.3E-08	0.01	2.4E-09	0.005	2.7E-06	0.00005	4.8E-05	5.0E-05
Aluminum	17000	1	5.5E-04	0.01	9.9E-05	ND		ND		
Chromium VI	6.48	1	2.1E-07	0.01	3.8E-08	0.005	4.2E-05	0.00055	6.8E-05	1.1E-04
Chromium III	58.32	1	1.9E-06	0.01	3.4E-07	1	1.9E-06	0.1	3.4E-06	5.3E-06
Copper	42.9	1	1.4E-06	0.01	2.5E-07	ND		ND		
Vanadium	48.6	1	1.6E-06	0.01	2.8E-07	0.007	2.3E-04	0.00021	1.3E-03	1.6E-03
Zinc	690	1	2.3E-05	0.01	4.0E-06	0.3	7.5E-05	0.102	3.9E-05	1.1E-04
Mercury	0.72	1	2.3E-08	0.01	4.2E-09	0.0003	7.8E-05	0.00006	7.0E-05	1.5E-04
Lead	570	0.3	5.6E-06	0.01	3.3E-06	ND		ND		
P,P-DDD	6.2	0.3	6.1E-08	0.05	1.8E-07	0.0005	1.2E-04	0.0001	1.8E-03	1.9E-03
Bis(2-ethylhexyl)phthalate	2	1	6.5E-08	0.5	5.8E-07	0.02	3.3E-06	0.02	2.9E-05	3.2E-05
Benzo(a)pyrene	6	1	2.0E-07	0.05	1.7E-07	0.04	4.9E-06	0.04	4.4E-06	9.3E-06
Benzo(b)fluoranthene	5	1	1.6E-07	0.05	1.5E-07	0.04	4.1E-06	0.04	3.6E-06	7.7E-06
Benzo(k)fluoranthene	10	1	3.3E-07	0.05	2.9E-07	0.04	8.2E-06	0.04	7.3E-06	1.5E-05
Indeno(1,2,3-cd)pyrene	2	1	6.5E-08	0.05	5.8E-08	0.04	1.6E-06	0.04	1.5E-06	3.1E-06

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE M-14, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - MAXIMUM EXPOSURE
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Acenaphthylene	3	1	9.8E-08	0.05	8.7E-08	0.04	2.4E-06	0.04	2.2E-06	4.6E-06
Anthracene	3	1	9.8E-08	0.05	8.7E-08	0.3	3.3E-07	0.273	3.2E-07	6.5E-07
Benzo(g,h,i)perylene	1	1	3.3E-08	0.05	2.9E-08	0.04	8.2E-07	0.04	7.3E-07	1.5E-06
Calcium	41600	1	1.4E-03	0.01	2.4E-04	ND		ND		
Iron	45000	1	1.5E-03	0.01	2.6E-04	ND		ND		
Potassium	3580	1	1.2E-04	0.01	2.1E-05	ND		ND		
Magnesium	7160	1	2.3E-04	0.01	4.2E-05	ND		ND		
Sodium	1860	1	6.1E-05	0.01	1.1E-05	ND		ND		
P,P-DDT	15	0.3	1.5E-07	0.05	4.4E-07	0.0005	2.9E-04	0.0001	4.4E-03	4.7E-03
Acenaphthene	0.87	1	2.8E-08	0.05	2.5E-08	0.06	4.7E-07	0.0546	4.6E-07	9.4E-07
Dibenzofuran	0.61	1	2.0E-08	0.05	1.8E-08	ND		ND		
Fluorene	0.2	1	6.5E-09	0.05	5.8E-09	0.04	1.6E-07	0.04	1.5E-07	3.1E-07
Naphthalene	0.25	1	8.2E-09	0.05	7.3E-09	0.04	2.0E-07	0.04	1.8E-07	3.9E-07
Cobalt	19.6	1	6.4E-07	0.01	1.1E-07	ND		ND		
Selenium	5.77	1	1.9E-07	0.01	3.4E-08	0.005	3.8E-05	0.003	1.1E-05	4.9E-05
Silver	6.35	1	2.1E-07	0.01	3.7E-08	0.005	4.1E-05	0.00105	3.5E-05	7.7E-05
					SUMMARY HAZARD INDEX		4E-02		2E-02	6E-02

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE M-15
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND – AVERAGE EXPOSURE
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	100	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365\ \text{days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM\ (SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

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TABLE M-15, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
P,P-DDE	0.09	0.3	2.5E-09	0.05	7.5E-09	3.40E-01	8.6E-10	1.7E+00	1.3E-08	1.4E-08
Benzo(a)anthracene	0.51	1	4.8E-08	0.05	4.2E-08	7.30E+00	3.5E-07	8.0E+00	3.4E-07	6.9E-07
Chrysene	0.63	1	5.9E-08	0.05	5.2E-08	7.30E+00	4.3E-07	8.0E+00	4.2E-07	8.5E-07
Arsenic	78	1	7.3E-06	0.01	1.3E-06	1.75E+00	1.3E-05	1.8E+00	2.3E-06	1.5E-05
Beryllium	0.19	1	1.8E-08	0.01	3.2E-09	4.30E+00	7.6E-08	4.3E+02	1.4E-06	1.4E-06
P,P-DDD	0.5	0.3	1.4E-08	0.05	4.2E-08	2.40E-01	3.4E-09	1.2E+00	5.0E-08	5.3E-08
Bis(2-ethylhexyl)phthalate	1.4	1	1.3E-07	0.5	1.2E-06	1.40E-02	1.8E-09	1.4E-02	1.6E-08	1.8E-08
Benzo(a)pyrene	1.1	1	1.0E-07	0.05	9.1E-08	7.30E+00	7.5E-07	8.0E+00	7.3E-07	1.5E-06
Benzo(b)fluoranthene	0.64	1	6.0E-08	0.05	5.3E-08	7.30E+00	4.4E-07	8.0E+00	4.3E-07	8.6E-07
Benzo(k)fluoranthene	0.9	1	8.4E-08	0.05	7.5E-08	7.30E+00	6.1E-07	8.0E+00	6.0E-07	1.2E-06
Indeno(1,2,3-cd)pyrene	0.56	1	5.2E-08	0.05	4.6E-08	7.30E+00	3.8E-07	8.0E+00	3.7E-07	7.5E-07
P,P-DDT	0.64	0.3	1.8E-08	0.05	5.3E-08	3.40E-01	6.1E-09	1.7E+00	9.0E-08	9.6E-08
					SUMMARY CANCER RISK		2E-05		7E-06	2E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE M-15, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND – AVERAGE EXPOSURE
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
P,P-DDE	0.09	0.3	1.8E-08	0.05	5.2E-08	0.0005	3.5E-05	0.0001	5.2E-04	5.6E-04
Benzo(a)anthracene	0.51	1	3.3E-07	0.05	3.0E-07	0.04	8.3E-06	0.04	7.4E-06	1.6E-05
Chrysene	0.63	1	4.1E-07	0.05	3.7E-07	0.04	1.0E-05	0.04	9.2E-06	1.9E-05
Arsenic	78	1	5.1E-05	0.01	9.1E-06	0.0003	1.7E-01	0.000294	3.1E-02	2.0E-01
Fluoranthene	1.6	1	1.0E-06	0.05	9.3E-07	0.04	2.6E-05	0.0364	2.6E-05	5.2E-05
Phenanthrene	0.77	1	5.0E-07	0.05	4.5E-07	0.04	1.3E-05	0.04	1.1E-05	2.4E-05
Pyrene	2.2	1	1.4E-06	0.05	1.3E-06	0.03	4.8E-05	0.0273	4.7E-05	9.5E-05
Barium	36.8	1	2.4E-05	0.01	4.3E-06	0.07	3.4E-04	0.0049	8.7E-04	1.2E-03
Manganese	634	1	4.1E-04	0.01	7.4E-05	0.14	3.0E-03	0.0056	1.3E-02	1.6E-02
Nickel	10.8	1	7.0E-06	0.01	1.3E-06	0.02	3.5E-04	0.001	1.3E-03	1.6E-03
Beryllium	0.19	1	1.2E-07	0.01	2.2E-08	0.005	2.5E-05	0.00005	4.4E-04	4.7E-04
Aluminum	6108	1	4.0E-03	0.01	7.1E-04	ND		ND		ND
Chromium VI	1.51	1	9.8E-07	0.01	1.8E-07	0.005	2.0E-04	0.00055	3.2E-04	5.2E-04
Chromium III	13.59	1	8.9E-06	0.01	1.6E-06	1	8.9E-06	0.1	1.6E-05	2.5E-05
Copper	8.5	1	5.5E-06	0.01	9.9E-07	ND		ND		
Vanadium	12.1	1	7.9E-06	0.01	1.4E-06	0.007	1.1E-03	0.00021	6.7E-03	7.8E-03
Zinc	82.3	1	5.4E-05	0.01	9.6E-06	0.3	1.8E-04	0.102	9.4E-05	2.7E-04
Mercury	0.077	1	5.0E-08	0.01	9.0E-09	0.0003	1.7E-04	0.00006	1.5E-04	3.2E-04
Lead	69.5	0.3	1.4E-05	0.01	8.1E-06	ND		ND		
P,P-DDD	0.5	0.3	9.8E-08	0.05	2.9E-07	0.0005	2.0E-04	0.0001	2.9E-03	3.1E-03
Bis(2-ethylhexyl)phthalate	1.4	1	9.1E-07	0.5	8.1E-06	0.02	4.6E-05	0.02	4.1E-04	4.5E-04
Benzo(a)pyrene	1.1	1	7.2E-07	0.05	6.4E-07	0.04	1.8E-05	0.04	1.6E-05	3.4E-05
Benzo(b)fluoranthene	0.64	1	4.2E-07	0.05	3.7E-07	0.04	1.0E-05	0.04	9.3E-06	2.0E-05
Benzo(k)fluoranthene	0.9	1	5.9E-07	0.05	5.2E-07	0.04	1.5E-05	0.04	1.3E-05	2.8E-05
Indeno(1,2,3-cd)pyrene	0.56	1	3.7E-07	0.05	3.3E-07	0.04	9.1E-06	0.04	8.1E-06	1.7E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE M-15, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Acenaphthylene	0.26	1	1.7E-07	0.05	1.5E-07	0.04	4.2E-06	0.04	3.8E-06	8.0E-06
Anthracene	0.27	1	1.8E-07	0.05	1.6E-07	0.3	5.9E-07	0.273	5.7E-07	1.2E-06
Benzo(g,h,i)perylene	0.48	1	3.1E-07	0.05	2.8E-07	0.04	7.8E-06	0.04	7.0E-06	1.5E-05
Calcium	8582	1	5.6E-03	0.01	1.0E-03	ND		ND		
Iron	15232	1	9.9E-03	0.01	1.8E-03	ND		ND		
Potassium	758	1	4.9E-04	0.01	8.8E-05	ND		ND		
Magnesium	2246	1	1.5E-03	0.01	2.6E-04	ND		ND		
Sodium	452	1	2.9E-04	0.01	5.3E-05	ND		ND		
P,P-DDT	0.64	0.3	1.3E-07	0.05	3.7E-07	0.0005	2.5E-04	0.0001	3.7E-03	4.0E-03
Acenaphthene	0.18	1	1.2E-07	0.05	1.0E-07	0.06	2.0E-06	0.0546	1.9E-06	3.9E-06
Dibenzofuran	0.15	1	9.8E-08	0.05	8.7E-08	ND		ND		
Fluorene	0.16	1	1.0E-07	0.05	9.3E-08	0.04	2.6E-06	0.04	2.3E-06	4.9E-06
Naphthalene	0.14	1	9.1E-08	0.05	8.1E-08	0.04	2.3E-06	0.04	2.0E-06	4.3E-06
Cobalt	3.38	1	2.2E-06	0.01	3.9E-07	ND		ND		
Selenium	1.96	1	1.3E-06	0.01	2.3E-07	0.005	2.6E-04	0.003	7.6E-05	3.3E-04
Silver	0.65	1	4.2E-07	0.01	7.6E-08	0.005	8.5E-05	0.00105	7.2E-05	1.6E-04
					SUMMARY HAZARD INDEX		2E-01		6E-02	2E-01

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

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TABLE M-16
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND – MAXIMUM EXPOSURE
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FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SEDIMENT	CS	chemical specific	mg/kg	
INGESTION RATE	IR	100	mg/day	USEPA, 1991b
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	0.5	mg/cm²-event	USEPA, 1992d
AGE-SPECIFIC SURFACE AREA	SA_i	age-specific	cm²	USEPA, 1989b
ABSORPTION FRACTION	ABS_i/ABS_d	default	unitless	USEPA, 1989c
CONVERSION FACTOR	CF	1.00E-06	kg/mg	
BODY WEIGHT	BW	42	kg	USEPA, 1989b
AGE-SPECIFIC BODY WEIGHT	BW_i	age-specific	kg	USEPA, 1989b
EXPOSURE FREQUENCY	EF	100	days/year *	Assumption
EXPOSURE DURATION	ED	10	years	Assumption
AGE-SPECIFIC EXPOSURE DURATION	ED_i	age-specific	years	Appendix V (USEPA, 1992d)
AGE-WEIGHTED SURFACE AREA [1]	$SA_{sed/adj}$	848.6	cm2-year/kg	Appendix V (USEPA, 1992d)
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989f
NONCANCER	AT	10	years	USEPA, 1989f

* Units for exposure frequency are in events/year in the calculation of the dermally absorbed dose.
[1] The calculations for normalized surface area ($SA_{sed/adj}$) and dermally absorbed dose per unit area per event (DA_{event}) are described in Appendix V.
USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.
USEPA, 1991b. "Standard Default Exposure Factors".
USEPA, 1989b. Exposure Factors Handbook.
USEPA, 1989c. Region I Supplemental Risk Assessment Guidance.
USEPA, 1989f. Risk Assessment Guidance for Superfund.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x ORAL CSF (mg/kg-day) ^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / ORAL RfD (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times ABS_i \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = (DA_{event} \times EF / AT \times 365\ \text{days/year}) \times SA_{sed/adj}$$

Where:

$$SA_{sed/adj} = SUM\ (SA_i \times ED_i / BW_i)$$
$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note:
For noncarcinogenic effects: AT = ED

TABLE M-16, continued
SEDIMENT INGESTION AND CONTACT - ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND - MAXIMUM EXPOSURE
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CARCINOGENIC EFFECTS

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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL CSF (mg/kg-day)^-1	CANCER RISK INGESTION	DERMAL CSF [2] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
P,P-DDE	0.72	0.3	2.0E-08	0.05	6.0E-08	3.40E-01	6.8E-09	1.7E+00	1.0E-07	1.1E-07
Benzo(a)anthracene	4	1	3.7E-07	0.05	3.3E-07	7.30E+00	2.7E-06	8.0E+00	2.7E-06	5.4E-06
Chrysene	8	1	7.5E-07	0.05	6.6E-07	7.30E+00	5.4E-06	8.0E+00	5.3E-06	1.1E-05
Arsenic	390	1	3.6E-05	0.01	6.5E-06	1.75E+00	6.4E-05	1.8E+00	1.2E-05	7.5E-05
Beryllium	0.41	1	3.8E-08	0.01	6.8E-09	4.30E+00	1.6E-07	4.3E+02	2.9E-06	3.1E-06
P,P-DDD	6.2	0.3	1.7E-07	0.05	5.1E-07	2.40E-01	4.2E-08	1.2E+00	6.2E-07	6.6E-07
Bis(2-ethylhexyl)phthalate	2	1	1.9E-07	0.5	1.7E-06	1.40E-02	2.6E-09	1.4E-02	2.3E-08	2.6E-08
Benzo(a)pyrene	6	1	5.6E-07	0.05	5.0E-07	7.30E+00	4.1E-06	8.0E+00	4.0E-06	8.1E-06
Benzo(b)fluoranthene	5	1	4.7E-07	0.05	4.2E-07	7.30E+00	3.4E-06	8.0E+00	3.3E-06	6.7E-06
Benzo(k)fluoranthene	10	1	9.3E-07	0.05	8.3E-07	7.30E+00	6.8E-06	8.0E+00	6.7E-06	1.3E-05
Indeno(1,2,3-cd)pyrene	2	1	1.9E-07	0.05	1.7E-07	7.30E+00	1.4E-06	8.0E+00	1.3E-06	2.7E-06
P,P-DDT	15	0.3	4.2E-07	0.05	1.2E-06	3.40E-01	1.4E-07	1.7E+00	2.1E-06	2.3E-06
					SUMMARY CANCER RISK		9E-05		4E-05	1E-04

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral CSFs as described in Section 6.1.2.3.

TABLE M-16, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND – MAXIMUM EXPOSURE
FUTURE LAND USE
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FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

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COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
P,P-DDE	0.72	0.3	1.4E-07	0.05	4.2E-07	0.0005	2.8E-04	0.0001	4.2E-03	4.5E-03
Benzo(a)anthracene	4	1	2.6E-06	0.05	2.3E-06	0.04	6.5E-05	0.04	5.8E-05	1.2E-04
Chrysene	8	1	5.2E-06	0.05	4.6E-06	0.04	1.3E-04	0.04	1.2E-04	2.5E-04
Arsenic	390	1	2.5E-04	0.01	4.5E-05	0.0003	8.5E-01	0.000294	1.5E-01	1.0E+00
Fluoranthene	10	1	6.5E-06	0.05	5.8E-06	0.04	1.6E-04	0.0364	1.6E-04	3.2E-04
Phenanthrene	6	1	3.9E-06	0.05	3.5E-06	0.04	9.8E-05	0.04	8.7E-05	1.9E-04
Pyrene	20	1	1.3E-05	0.05	1.2E-05	0.03	4.3E-04	0.0273	4.3E-04	8.6E-04
Barium	115	1	7.5E-05	0.01	1.3E-05	0.07	1.1E-03	0.0049	2.7E-03	3.8E-03
Manganese	3000	1	2.0E-03	0.01	3.5E-04	0.14	1.4E-02	0.0056	6.2E-02	7.6E-02
Nickel	54.3	1	3.5E-05	0.01	6.3E-06	0.02	1.8E-03	0.001	6.3E-03	8.1E-03
Beryllium	0.41	1	2.7E-07	0.01	4.8E-08	0.005	5.3E-05	0.00005	9.5E-04	1.0E-03
Aluminum	17000	1	1.1E-02	0.01	2.0E-03	ND		ND		
Chromium VI	6.48	1	4.2E-06	0.01	7.5E-07	0.005	8.5E-04	0.00055	1.4E-03	2.2E-03
Chromium III	58.32	1	3.8E-05	0.01	6.8E-06	1	3.8E-05	0.1	6.8E-05	1.1E-04
Copper	42.9	1	2.8E-05	0.01	5.0E-06	ND		ND		
Vanadium	48.6	1	3.2E-05	0.01	5.6E-06	0.007	4.5E-03	0.00021	2.7E-02	3.1E-02
Zinc	690	1	4.5E-04	0.01	8.0E-05	0.3	1.5E-03	0.102	7.9E-04	2.3E-03
Mercury	0.72	1	4.7E-07	0.01	8.4E-08	0.0003	1.6E-03	0.00006	1.4E-03	3.0E-03
Lead	570	0.3	1.1E-04	0.01	6.6E-05	ND		ND		
P,P-DDD	6.2	0.3	1.2E-06	0.05	3.6E-06	0.0005	2.4E-03	0.0001	3.6E-02	3.8E-02
Bis(2-ethylhexyl)phthalate	2	1	1.3E-06	0.5	1.2E-05	0.02	6.5E-05	0.02	5.8E-04	6.5E-04
Benzo(a)pyrene	6	1	3.9E-06	0.05	3.5E-06	0.04	9.8E-05	0.04	8.7E-05	1.9E-04
Benzo(b)fluoranthene	5	1	3.3E-06	0.05	2.9E-06	0.04	8.2E-05	0.04	7.3E-05	1.5E-04
Benzo(k)fluoranthene	10	1	6.5E-06	0.05	5.8E-06	0.04	1.6E-04	0.04	1.5E-04	3.1E-04
Indeno(1,2,3-cd)pyrene	2	1	1.3E-06	0.05	1.2E-06	0.04	3.3E-05	0.04	2.9E-05	6.2E-05

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

TABLE M-16, continued
SEDIMENT INGESTION AND CONTACT – ADOLESCENT, AGES 6 TO 16
COLD SPRING BROOK POND – MAXIMUM EXPOSURE
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REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA
NONCARCINOGENIC EFFECTS

COMPOUND	SEDIMENT CONCENTRATION (mg/kg)	INGESTION ABS [1]	INTAKE INGESTION (mg/kg-day)	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Acenaphthylene	3	1	2.0E-06	0.05	1.7E-06	0.04	4.9E-05	0.04	4.4E-05	9.3E-05
Anthracene	3	1	2.0E-06	0.05	1.7E-06	0.3	6.5E-06	0.273	6.4E-06	1.3E-05
Benzo(g,h,i)perylene	1	1	6.5E-07	0.05	5.8E-07	0.04	1.6E-05	0.04	1.5E-05	3.1E-05
Calcium	41600	1	2.7E-02	0.01	4.8E-03	ND		ND		
Iron	45000	1	2.9E-02	0.01	5.2E-03	ND		ND		
Potassium	3580	1	2.3E-03	0.01	4.2E-04	ND		ND		
Magnesium	7160	1	4.7E-03	0.01	8.3E-04	ND		ND		
Sodium	1860	1	1.2E-03	0.01	2.2E-04	ND		ND		
P,P-DDT	15	0.3	2.9E-06	0.05	8.7E-06	0.0005	5.9E-03	0.0001	8.7E-02	9.3E-02
Acenaphthene	0.87	1	5.7E-07	0.05	5.1E-07	0.06	9.5E-06	0.0546	9.3E-06	1.9E-05
Dibenzofuran	0.61	1	4.0E-07	0.05	3.5E-07	ND		ND		
Fluorene	0.2	1	1.3E-07	0.05	1.2E-07	0.04	3.3E-06	0.04	2.9E-06	6.2E-06
Naphthalene	0.25	1	1.6E-07	0.05	1.5E-07	0.04	4.1E-06	0.04	3.6E-06	7.7E-06
Cobalt	19.6	1	1.3E-05	0.01	2.3E-06	ND		ND		
Selenium	5.77	1	3.8E-06	0.01	6.7E-07	0.005	7.5E-04	0.003	2.2E-04	9.8E-04
Silver	6.35	1	4.1E-06	0.01	7.4E-07	0.005	8.3E-04	0.00105	7.0E-04	1.5E-03
					SUMMARY HAZARD INDEX		9E-01		4E-01	1E+00

[1] Set equal to USEPA Region I default absorption factors for soil (USEPA, 1989c).
[2] Calculated from Oral RfDs as described in Section 6.1.2.3.
ND = No data available

FISH TISSUE COMPARISON OF STATE AND NATIONAL DATA

APPENDIX N

1.0 INTRODUCTION

As detailed in Sections 7.1.2 and 7.2.2 of the Group 1A supplemental risk assessments, the fish tissue whole body contaminant burdens at Plow Shop Pond and Cold Spring Brook Pond were evaluated through empirical and statistical comparisons of fish tissue data with data from regional and national studies of fish tissue contaminant burden. Average fish tissue contaminant burdens were compared to regional background fish tissue contaminant data, as described in Subsections 2.1 and 3.1 of this appendix, and maximum fish tissue contaminant burdens were compared to national fish tissue contaminant data, as described in Subsections 2.2 and 3.2 of this appendix.

2.0 SHEPLEY'S HILL LANDFILL

2.1 REGIONAL COMPARISON

Fish tissue contaminant data from 11 different ponds, lakes, reservoirs, and rivers within Massachusetts were obtained from the MADWPC (1988a; 1988b; 1989; 1990; 1991). Because Plow Shop Pond is a shallow, eutrophic pond, ponds with mesotrophic or oligotrophic status were excluded from the subset used as the "background" standard of comparison; information on the limnological status of water bodies in the MADWPC database was obtained through consultation with the MADWPC Biomonitoring Program office (Maietta, 1993). Additionally, aquatic resources with known or suspected sources of contamination were also eliminated from the subset used as the Group 1A standard of comparison. The subset of fish tissue contaminant burden data in the remaining ponds was considered representative of background conditions in a warmwater eutrophic fishery in Massachusetts (Table N-1).

Summary statistics were calculated from the selected subset of the MADWPC fish tissue database for inorganics, PCBs (Aroclors 1254 and 1260), and a pesticide (DDE) (Tables N-2 and N-3). Sample sizes of the MADWPC data ranged from nine for lead to 34 for the analytes iron, mercury, manganese, and Aroclor 1260. When an inorganic or organic analyte was undetected in all fish from a given water body, these data were excluded from the calculation of summary statistics

for that analyte. The average, maximum, and 95th percent confidence intervals for the MADWPC fish data are presented in Table N-4.

In order to determine whether the fish tissue contaminant burden in Plow Shop Pond fish was greater or less than fish tissue concentrations from non-contaminated water bodies in the region, the average tissue contaminant burdens from Plow Shop Pond fish were compared with the average concentrations calculated from the selected subset of MADWPC regional fish tissue data. Because of the limited data sets available from the MADWPC, a decision was made to not attempt to partition the entire reference database into trophic level data subsets for statistical analyses. However, a qualitative trophic level partitioning of the inorganics MADWPC database is presented in Table N-5. The fish collected from the selected subset of the MADWPC fish tissue database were segregated into the trophic levels represented by the bluegill (primary consumer), bullhead (bottom feeder), and the largemouth bass (secondary/tertiary consumer) (Table N-5). Averages, ranges, and standard errors on the averages were then derived for each inorganic to characterize the exposure to these trophic levels. Each trophic level was assumed to be represented in Table N-5 by the following species:

Primary Consumer **(Bluegill)**	**Bottom Feeder** **(Bullhead)**	**Secondary/Tertiary Consumer** **(Largemouth Bass)**
White Perch	White sucker	Largemouth bass
Yellow Perch	Carp	Smallmouth bass
Pumpkinseed	Yellow bullhead	Chain pickerel
Bluegill		

No statistical analyses of potential trophic level differences in average fish tissue contaminant burdens between Plow Shop Pond and the regional data set were conducted because of the limited data available from the MADWPC.

2.1.1 Bluegills

Average whole body contaminant burdens of aluminum, chromium, iron, manganese, and zinc in bluegills from Plow Shop Pond exceeded regional average contaminant burdens for all fish representing all trophic levels (Table N-6). The average Plow Shop Pond bluegill chromium contaminant burden was 0.656 micrograms per gram wet weight (μg/g ww) only 1.3 times greater than the regional background concentration. Average aluminum and zinc contaminant burdens in Plow Shop Pond bluegills were approximately 2.9 and 3.6 times greater than their respective concentrations in the MADWPC database. The average iron contaminant burden in bluegills was approximately 11 times greater than background, and the average manganese contaminant burden in bluegills (63.2 μg/g ww) was greater than 130 times the average of the MADWPC data subset. A comparison of average whole body contaminant burdens in bluegills from Plow Shop Pond with the primary consumer trophic level reference data (Table N-5) resulted in the identical inorganic analyte exceedances.

2.1.2 Bullheads

Average contaminant burdens of aluminum, iron, manganese, and zinc in bullheads from Plow Shop Pond exceeded regional average contaminant burdens in all fish representing all trophic levels (Table N-7). The average Plow Shop Pond bullhead aluminum and zinc contaminant burdens were 1.8 and 2.3 times greater than their respective regional background concentrations. The average iron contaminant burden in bullheads was approximately 5 times greater than background, and the average manganese contaminant burden (9.46 μg/g ww) was approximately 20 times the selected MADWPC background concentration. Average contaminant burdens of aluminum, chromium, mercury, manganese, and zinc in bullheads from Plow Shop Pond exceeded the corresponding bottom-feeder trophic level reference data (Table N-5). Exceedances ranged from approximately 2 times (aluminum) to 20 times (manganese) the MADWPC reference data. Mercury was detected in Plow Shop Pond bullheads at contaminant burdens approximately 6 times the MADWPC bottom feeder average.

2.1.3 Largemouth Bass

Average contaminant burdens of a pesticide (DDE), a PCB (Aroclor 1260), aluminum, iron, manganese, mercury, and zinc in largemouth bass from Plow Shop Pond exceeded regional average concentrations in all fish representing all trophic levels (Table N-8). The average Plow Shop Pond largemouth bass aluminum and zinc contaminant burdens were 1.5 and 2.3 times greater than their respective regional background concentrations. The average iron contaminant burden in bass was approximately 2.2 times greater than background, and the average manganese contaminant burden was approximately 13.2 times greater than the selected MADWPC background concentration. Mercury was found in all five largemouth bass from Plow Shop Pond at an average contaminant burden of 1.38 μg/g ww, approximately 2.3 times the MADWPC background concentration of mercury. The pesticide DDE was found at an average contaminant burden of 0.174 μg/g ww. This average contaminant burden is approximately 7.5 times the MADWPC background concentration. Average whole body contaminant burdens for aluminum, chromium, iron, mercury, manganese, and zinc in largemouth bass from Plow Shop Pond exceeded corresponding higher trophic level reference data (Table N-5) by 1.3 times (mercury) to 14 times (manganese). Chromium was detected in Plow Shop Pond largemouth bass at contaminant burdens approximately 1.4 times the MADWPC higher trophic level average.

2.1.4 All Whole Fish

Results of comparisons between the MADWPC regional database and all whole fish from Plow Shop Pond (i.e., the 15 individual fish representing three species) are presented in Table N-9. The average fish tissue contaminant burden from Plow Shop Pond exceeded the MADWPC regional averages for the following analytes: DDE, aluminum, iron, manganese, mercury, and zinc. The average Plow Shop Pond fish mercury contaminant burden (0.68 μg/g ww) was only slightly higher than 0.6 μg/g ww, the average mercury concentration in the MADWPC regional database (Table N-2). Aluminum, zinc, and DDE contaminant burdens were 2 to 3 times greater than their respective regional background concentrations. The average iron contaminant burden in all fish was approximately 6 times greater than background, and the average manganese contaminant burden was approximately 55 times greater than the MADWPC background concentration.

2.1.4.1 Statistical Analyses. When the average tissue contaminant burdens for all 15 individual fish from Plow Shop exceeded regional average concentrations (Table N-9), a statistical analysis was conducted through Student's t-test comparisons of the averages ($\alpha = 0.05$) using the T-TEST procedure of SYSTAT[R] statistical software (SYSTAT, Inc., Evanston, IL). Multiple comparisons of averages were one-tailed and designed to identify Plow Shop Pond average COPC concentrations that were statistically greater ($P < 0.05$) than concentrations for analytes from the regional MADWPC database.

Results of the statistical comparisons between all fish from Plow Shop Pond and the MADWPC regional database are summarized in Figure N-1. The average contaminant burdens of aluminum, iron, manganese, and zinc in Plow Shop Pond were significantly greater ($P < 0.05$) than average concentrations for whole fish from the regional database.

2.2 National Comparison

The National Contaminant Biomonitoring Program (NCBMP) is maintained by the U.S. Fish and Wildlife Service to document spatial and temporal trends in levels of persistent environmental contaminates in fish and wildlife (Jacknow et al., 1986). Composite fish samples analyzed through the NCBMP each comprise 3 to 5 adult specimens of a given fish species. Freshwater fish organochlorine (i.e., pesticides/PCBs) and inorganics tissue data collected by USFWS from more than 100 stations located nationwide have been summarized by the NCBMP (Schmitt et al., 1990; Schmitt and Brumbaugh, 1990).

In order to determine whether the fish tissue inorganic contaminant burden in Plow Shop Pond fish was greater or less than fish tissue inorganic contaminant burdens from water bodies elsewhere in the nation, the maximum inorganic tissue contaminant burdens from Plow Shop Pond fish were compared with the NCBMP 85th percentile concentration of Schmitt and Brumbaugh (1990). Because Schmitt et al. (1990) do not present the 85th percentile concentration for pesticides/PCBs, the maximum concentrations in the NCBMP for pesticides/PCBs were compared with the maximum tissue contaminant burden of fish from Plow Shop Pond. The maximum (organics) and 85th percentile (inorganics) concentrations for the NCBMP fish data are presented in Table N-4.

2.2.1 Bluegills

Maximum contaminant burdens of arsenic and mercury in bluegills from Plow Shop Pond exceeded national 85th percentile concentrations (Table N-6). Arsenic was detected in one of five bluegill from Plow Shop Pond, at a contaminant burden of 1.3 μg/g ww, approximately 4.8 times the NCBMP 85th percentile concentration. Mercury was found in all five bluegills analyzed, at a maximum contaminant burden of 0.54 μg/g ww. This contaminant burden is approximately 3 times the NCBMP 85th percentile concentration.

2.2.2 Bullheads

Maximum contaminant burdens of arsenic, copper, and mercury in bullheads from Plow Shop Pond exceeded national 85th percentile concentrations (Table N-7). Arsenic was detected in one of five bullheads from Plow Shop Pond, at a contaminant burden of 0.3 μg/g ww, slightly higher than the NCBMP 85th percentile concentration (0.27 μg/g ww). Copper was also detected at a maximum contaminant burden (1.3 μg/g ww) only slightly in excess of its NCBMP 85th percentile concentration (1 μg/g ww). Mercury was found in all five bullheads analyzed, at a maximum contaminant burden of 0.4 μg/g ww. This contaminant burden is approximately 2 times the NCBMP 85th percentile concentration for mercury.

2.2.3 Largemouth Bass

Maximum contaminant burdens of cadmium and mercury in largemouth bass from Plow Shop Pond exceeded the national 85th percentile concentration (Table N-8). Mercury was found in all five largemouth bass analyzed, at a maximum contaminant burden of 2.7 μg/g ww. This contaminant burden is almost 16 times the NCBMP 85th percentile concentration for mercury. Cadmium was found in only one of the five largemouth bass, at a contaminant burden of 0.09 μg/g ww, approximately twice the NCBMP 85th percentile concentration for cadmium. Contaminant burdens of pesticides and PCBs in Plow Shop Pond largemouth bass did not exceed the maximum concentrations of these analytes in the NCBMP.

2.2.4 All Whole Fish

Results of comparisons between the NCBMP data and all whole fish from Plow Shop Pond (i.e., the 15 individual fish representing three species) are presented in Table N-9. As discussed previously, the maximum Plow Shop Pond whole fish tissue contaminant burdens of arsenic, cadmium, copper, and mercury exceeded their respective NCBMP 85th percentile concentrations.

2.3 BODY WEIGHT AND LIPID ANALYSIS

Mercury and several organochlorines were detected in Plow Shop Pond fish. These analytes are known to bioaccumulate in biotic tissues; therefore, tissue contaminant burdens of mercury and DDE were evaluated further relative to body weight and lipid content. Although no information is available regarding the ionic state of mercury in fish tissue at Plow Shop Pond, available evidence indicates that at least 80-90% of the mercury found in fish tissue is present as methylmercury, the more toxic form of this compound (Eisler, 1987; Moore, 1991). Methylation of inorganic mercury occurs as a result of bacterial processes in the sediment, as well as through biochemical interactions with fish mucus and enzymatic processes (Eisler, 1987).

Table N-10 presents whole body tissue residue contaminant burdens for DDE and mercury detected in the 15 fish samples analyzed. Both DDE and mercury contaminant burdens are correlated with fish body weight (r^2 = 0.73 and 0.92, respectively) and percent lipid (r^2 = 0.72 and 0.64, respectively). The highest contaminant burdens of both analytes were detected in the largemouth bass samples. Average weights of largemouth bass samples (1,972 grams) were greater than 10 times the average body weights of the bluegill sunfish (104 grams) and bullheads (186.6 grams). In addition, largemouth bass contained a greater percentage of body fat; average percent lipid in largemouth bass, bluegill, bullhead were 2.25%, 0.46%, and 0.87%, respectively. These results suggest that the tissue residue data may be correlated with the size and/or the lipid contaminant burden in the fish species analyzed, as well as with trophic status.

To determine whether the amount of body lipid could account for differences in tissue burdens of Plow Shop Pond fish samples, the whole body tissue residue contaminant burden data were lipid-normalized by dividing measured analyte

contaminant burdens by the percent lipid measured in each fish sample (Table N-10). These results were then regressed on sample body weight (a correlate of trophic status in the Plow Shop Pond samples).

Lipid-normalized DDE tissue contaminant burdens ranged over less than an order of magnitude (0.17 to 1.27 μg/kg lipid). In general, largemouth bass contained slightly higher lipid-normalized contaminant burdens than the other two species. A regression of lipid-normalized DDE fish tissue contaminant burdens on fish body weight indicated a positive, but weak correlation, between these two variables (r^2 = 0.58). Body weight and trophic status are correlated variables in the data set analyzed, as are a number of other factors that may be important in determining the degree of uptake of this analyte (e.g., age, reproductive phenology). This analysis suggests that larger fish, regardless of trophic status, contain slightly higher amounts of DDE; however, much of this variation can be accounted for by the amount of lipids contained by a particular individual.

Lipid-normalized tissue contaminant burdens of mercury ranged over two orders of magnitude (1.79 to 29.4 μg/kg lipid). The lowest adjusted contaminant burdens were found in the bullhead (Table N-10). Highest lipid-normalized mercury tissue contaminant burdens were detected in bluegill. A regression of lipid-normalized mercury fish tissue contaminant burdens on fish body weight indicated that these two variables are not correlated (r^2 = 0.0009). After taking account of differences in lipid content, there is no indication that larger (and higher trophic status) fish species have accumulated higher contaminant burdens of this analyte.

Fish body weight (and concomitantly trophic status) appears to be a good predictor of mercury contaminant burden in Plow Shop Pond, with higher trophic level fish species having accumulated higher contaminant burdens of this analyte.

3.0 COLD SPRING BROOK POND

3.1 REGIONAL COMPARISON

Summary statistics were calculated from the MADWPC fish tissue database for inorganics, PCBs (aroclors 1254 and 1260), and a pesticide (4,4-'DDE)

(Tables N-2 and N-3). The average, maximum, and upper and lower 95th percent confidence intervals for the MADWPC fish data are presented in Table N-4.

In order to determine whether the fish tissue contaminant burden in Cold Spring Brook Pond fish was greater or less than fish tissue concentrations from non-contaminated water bodies in the region, the average tissue contaminant burdens from Cold Spring Brook Pond fish were compared with the average contaminant burdens calculated from the selected subset of the MADWPC regional data.

3.1.1 Pumpkinseeds

Average whole body contaminant burdens of DDE, iron, manganese, and zinc in pumpkinseeds from Cold Spring Brook Pond exceeded regional average contaminant burdens (Table N-11). The average Cold Spring Brook Pond pumpkinseed DDE contaminant burden was 0.083 μg/g ww, 3.6 times greater than the regional background concentration. Average iron and zinc contaminant burdens in Cold Spring Brook Pond pumpkinseeds were approximately 4.5 and 3 times greater than their respective concentrations in the MADWPC database. The average manganese contaminant burden (10 μg/g ww) in pumpkinseeds was approximately 21 times greater than the MADWPC background concentration.

3.1.2 Bullhead

Average contaminant burdens of DDE, iron, manganese, and zinc in bullheads from Cold Spring Brook Pond exceeded regional average concentrations (Table N-12). The average Cold Spring Brook Pond bullhead iron and zinc contaminant burdens were 4.0 and 2.2 times greater than their respective regional background concentrations. The average DDE contaminant burden in bullheads was approximately 4 times greater than the selected background value, and the average manganese contaminant burden (7.1 μg/g ww) was approximately 15 times the MADWPC background concentration.

3.1.3 Chain Pickerel

Average contaminant burdens of one pesticide (DDE), iron, manganese, and zinc in chain pickerel from Cold Spring Brook Pond exceeded regional average concentrations (Table N-13). The average Cold Spring Brook Pond chain pickerel iron and zinc contaminant burdens were 1.8 and 6.2 times greater than their

respective regional background concentrations. The average DDE contaminant burden in pickerel was approximately 3.5 times greater than background, and the average manganese contaminant burden was approximately 20 times greater than the MADWPC background concentration.

3.1.4 All Whole Fish

Results of comparisons between the MADWPC regional database and all whole fish from Cold Spring Brook Pond (i.e., the nine individual fish representing three species) are presented in Table N-14. The average fish tissue contaminant burden from Cold Spring Brook Pond exceeded the MADWPC regional averages for the following analytes: DDE, iron, manganese, and zinc. DDE, iron, and zinc contaminant burdens were 3 to 4 times greater than their respective regional background concentrations. The average manganese contaminant burden was approximately 18.5 times greater than the MADWPC background concentration.

When the average tissue contaminant burdens for all nine individual fish from Cold Spring Brook Pond exceeded regional average concentrations, a statistical analysis was conducted through Student's T-test comparisons of the averages ($\alpha = 0.05$) using the T-TEST procedure of SYSTAT^{R} statistical software (SYSTAT, Inc., Evanston, IL). Multiple comparisons of averages were one-tailed and designed to identify Cold Spring Brook Pond averages which were statistically greater ($P < 0.05$) than averages for respective analytes from the regional MADWPC database.

Results of the statistical comparisons between all fish from Cold Spring Brook Pond and the MADWPC regional database are summarized in Figure N-2. The average contaminant burdens of DDE, iron, manganese, and zinc in Cold Spring Brook Pond were significantly greater ($P < 0.05$) than average concentrations for whole fish from the regional database.

3.2 National Comparison

In order to determine whether the fish tissue inorganic contaminant burden in Cold Spring Brook Pond fish was greater or less than fish tissues from water bodies elsewhere in the nation, the maximum inorganic tissue contaminant burdens from Cold Spring Brook Pond fish were compared with the NCBMP 85th

percentile concentration (i.e, the concentration ranked 85th highest on an analyte-specific basis) of Schmitt and Brumbaugh (1990). Because Schmitt et al. (1990) do not present the 85th percentile concentration for pesticides/PCBs, the maximum concentrations in the NCBMP for pesticides/PCBs were compared with the maximum tissue contaminant burden of fish from Cold Spring Brook Pond. The maximum (organics) and 85th percentile (inorganics) concentrations for the NCBMP fish data are presented in Table N-4.

3.2.1 Bullheads and Pumpkinseeds

None of the maximum contaminant burdens of the inorganics, pesticides, or PCBs detected in bullheads or pumpkinseeds from Cold Spring Brook Pond exceeded national 85th percentile concentrations (Tables N-11 and N-12).

3.2.2 Chain Pickerel

Maximum contaminant burdens of mercury and zinc in chain pickerel from Cold Spring Brook Pond exceeded the national 85th percentile concentration (Table N-13). Mercury was found in all three chain pickerel analyzed, at a maximum contaminant burden of 0.47 $\mu g/g$ ww. This contaminant burden is approximately 2.8 times the NCBMP 85th percentile concentration for mercury. Zinc was found in all three of the pickerel analyzed, at a maximum contaminant burden of 51.3 $\mu g/g$ ww, 1.5 times greater than the NCBMP 85th percentile concentration for zinc. Contaminant burdens of pesticides in Cold Spring Brook Pond pickerel did not exceed the maximum concentrations of the USFWS NCBMP.

3.2.3 All Whole Fish

Results of comparisons between the NCBMP data and all whole fish from Cold Spring Brook Pond (i.e., the nine individual fish representing three species) are presented in Table N-14. As discussed previously, the maximum Cold Spring Brook Pond whole fish tissue contaminant burdens of mercury and zinc exceeded their respective NCBMP 85th percentile concentrations.

3.3 BODY WEIGHT AND LIPID ANALYSIS

Mercury and several organochlorines were detected in Cold Spring Brook Pond fish. These analytes are known to bioaccumulate in biotic tissues; therefore, tissue contaminant burdens of mercury and 4,4-'DDE were evaluated further relative to body weight and lipid content.

Table N-15 presents the whole body tissue residue contaminant burdens for DDE and mercury detected in the 9 fish samples analyzed. DDE tissue contaminant burdens are not correlated with fish body weight (r^2 = 0.005); however, a strong correlation exist between mercury tissue contaminant burdens and fish body weight (r^2 = 0.85). Average weights of pickerel (222.7 grams) were over five times greater than the average body weights of the pumpkinseed sunfish (43 grams) and bullheads (34 grams). However, bullheads contained a greater percentage of body lipids; average percent lipids in bullhead, pumpkinseed, and pickerel were 2.71%, 1.19%, and 1.09%, respectively.

To determine whether the amount of body lipid could account for differences in tissue contaminant burdens in Cold Spring Brook Pond fish samples, the whole body tissue residue contaminant burden data were lipid-normalized by dividing measured analyte contaminant burdens by the percent lipid measured in each fish sample (Table N-15). These results were then regressed on sample body weight (a possible correlate of trophic status in the Cold Spring Brook Pond samples).

Lipid-normalized DDE tissue contaminant burdens ranged over less than an order of magnitude (0.23 to 1.07 μg/kg lipid). A regression of lipid-normalized DDE fish tissue contaminant burdens on fish body weight suggests that these two variables are not correlated (r^2 = 0.02). Lipid-normalized tissue contaminant burdens of mercury, ranged from 0.22 μg/kg lipid to 6.1 μg/kg lipid. As suggested by the lack of correlation between body weight and fish percentage lipid, the regression of lipid-normalized mercury fish tissue contaminant burdens on fish body weight indicated that these two variables are not correlated (r^2 = 0.17).

Fish body weight (and concomitantly trophic status) appears to be a good predictor of mercury contaminant burden in Cold Spring Brook Pond, with higher trophic level fish species having accumulated higher contaminant burdens of this analyte.

4.0 FISH SIZE DISTRIBUTION

Length and weight data from fish species collected in Plow Shop Pond are provided in Table N-16. Table N-16 also provides the analytical collection number for all individual fish collected for tissue analysis. Weights of bluegill, the dominant species in Plow Shop Pond, ranged from 9 to 137 grams, with an average weight of 50.6 grams. Bluegill lengths ranged from 79 to 203 mm, with an average length of 143.5 mm. In addition to bluegill, individual brown and yellow bullheads and largemouth bass were also collected for tissue analysis. Brown bullhead and largemouth bass weights ranged from 95 to 419 grams and 38 to 3480 grams, respectively. Lengths ranged from 211 to 324 mm and 71 to 545 mm for bullhead and largemouth bass, respectively.

Length and weight data from fish species collected in Cold Spring Brook Pond are provided in Table N-17. Table N-17 also provides the analytical collection number for all individual fish collected for tissue analysis. Weights of golden shiner, the dominant lower trophic level species in Cold Spring Brook Pond, ranged from 6 to 36 grams, with an average weight of 16.9 grams. Lengths ranged from 52 to 158 mm, with an average length of 123 mm. Individual fish collected for tissue analysis included chain pickerel, pumpkinseed, and yellow bullhead. Chain pickerel lengths and weights ranged from 210 to 398 mm and 44 to 418 grams, with averages of 324 mm and 215 grams, respectively. Pumpkinseed lengths and weights ranged from 70 to 143 mm and 17 to 56 grams, with averages of 113 mm and 34 grams, respectively. Yellow bullhead lengths and weights ranged from 38 to 167 mm and 31 to 73 grams, with averages of 133 mm and 50 grams, respectively.

Fish species collected in both Plow Shop Pond and Cold Spring Brook Pond included the black crappie, chain pickerel, golden shiner, pumpkinseed, and yellow bullhead. Comparison of average length and weight measurements between these fish species indicates that, in general, Plow Shop Pond fish are larger than Cold Spring Brook Pond fish. This is likely due to the larger, more diverse aquatic environment provided in Plow Shop Pond, which is approximately ten times larger in surface area than Cold Spring Brook Pond.

Figure N-1
Statistical Comparison of Means
Plow Shop Pond and MADWPC Data

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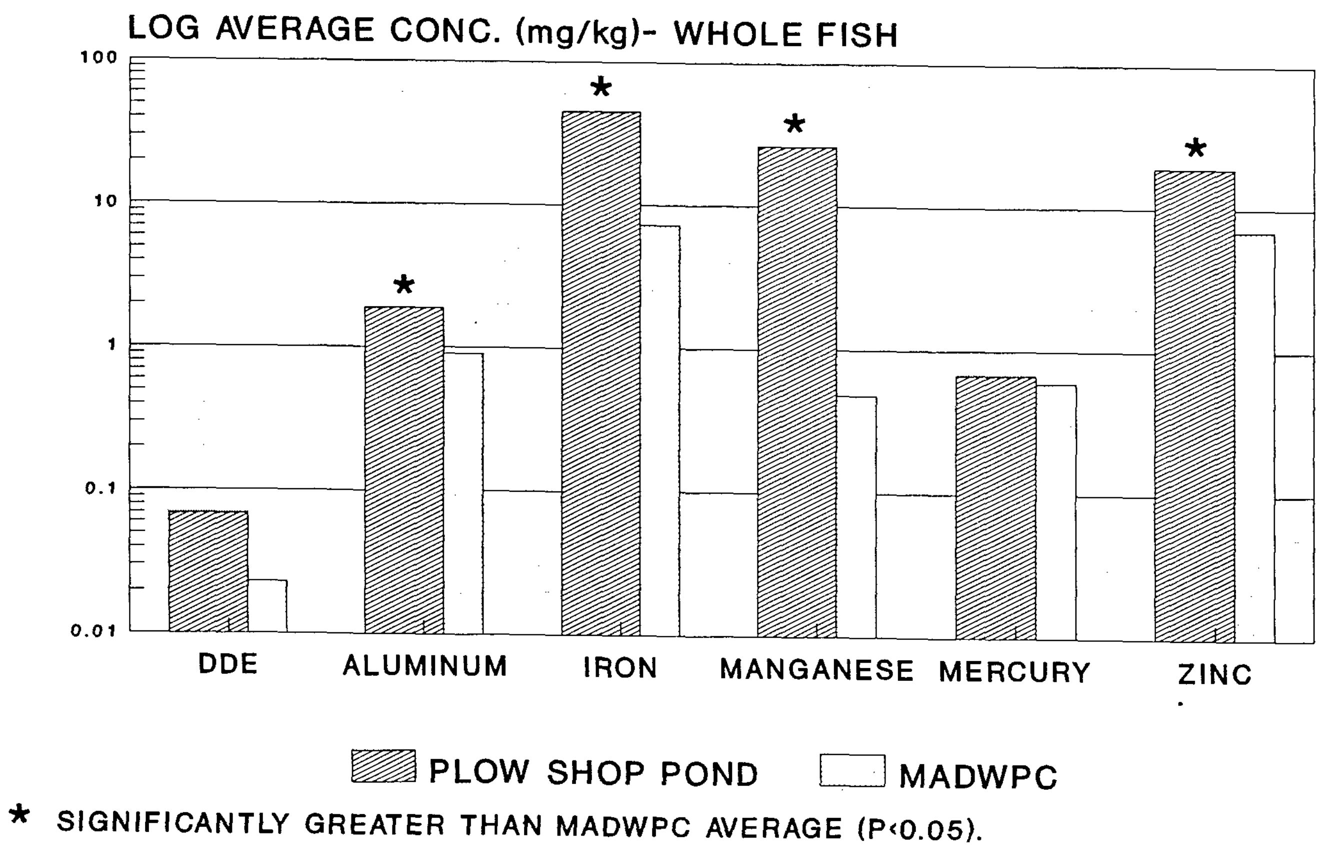

Figure N-2
Statistical Comparison of Means
Cold Spring Brook Pond and MADWPC Data

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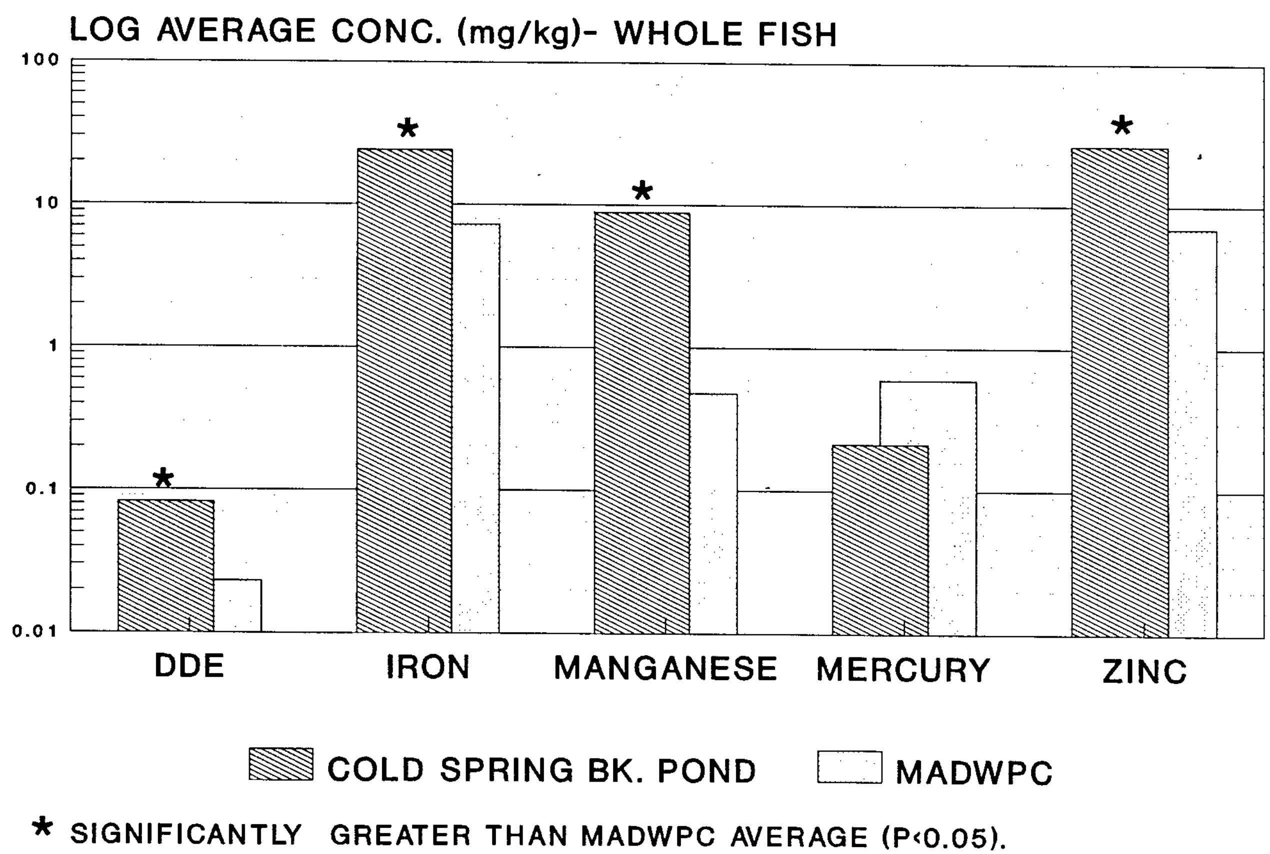

Table N-1

Sources of Regional Information Regarding Contaminants in Fish Tissues

Remedial Investigation Addendum Report

Feasibility Study for Group 1A Sites

Fort Devens, MA

SOURCES [a]	WATERBODY	GEOGRAPHIC LOCATION	TROPHIC STATES [b]	POTENTIAL IMPACTS?	INFORMATION UTILIZED
USFWS	VARIOUS- U.S.	VARIOUS- U.S.	VARIOUS	YES	YES (c,d,e)
MADWPC	ECHO LAKE	S. CENTRAL MA	OLIGOTROPHIC	NO	YES (d)
	WALDEN POND	N. EAST MA	OLIGOTROPHIC	NO	YES (d,e)
	SANDY POND	N. EAST MA	OLIGOTROPHIC	NO	NO
	COPICUT RIVER RES.	S. EAST MA	OLIGOTROPHIC	NO	YES (e)
	LAKE WABAN	MID-EASTERN MA	EUTROPHIC	YES	NO
	SUDBURY RIVER	MID-EASTERN MA	EUTROPHIC	YES	NO
	LAKE DENISON	N. CENTRAL MA	EUTROPHIC	YES	NO
	N. WATUPPA POND	S. EAST MA	MESOTROPHIC	NO	YES (c,e)
	S. WATUPPA POND	S. EAST MA	EUTROPHIC	NO	YES (c,e)
	DOROTHY POND	S. CENTRAL MA	EUTROPHIC	YES	YES (c,e)
	INDIAN LAKE	MID-CENTRAL MA	EUTROPHIC	NO	YES (c,e)

[a] Sources of Information:

United States Fish and Wildlife Service (USFWS) National Contaminant Biomonitoring Program (USFWS, 1990a; 1990b).

Massachusetts Department of Environmental Protection, Division of Water Pollution Control ([MADWPC], 1988a; 1988b; 1989a; 1989b; 1990; 1991).

[b] Trophic states determined by conversation with MADWPC Biomonitoring Program, North Grafton, MA (Maietta, 1993)

[c] Data for inorganic chemicals used.

[d] Data for DDE used.

[e] Data for PCBs used.

Table N-2

Inorganics in Whole Fish Tissues from Lacustrine Systems

In Massachusetts (1)

Remedial Investigation Addendum Report

Feasibility Study For Group 1A Sites

Fort Devens, MA

WATERBODY	FISH	SAMPLE	TYPE OF	INORGANIC ANALYTES (ug/g wet weight tissue) * (4,5)									
	CODE (2)	POPULATION	SAMPLE (3)	Al	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
N. WATUPPA POND	CP	1	IND.	2	ND(.2)	ND*(.3)	0.5	3.9	2.4	ND*(.2)	0.4	ND(.5)	10
n = 12	CP	1	IND.	1.2	ND(.2)	ND*(.3)	1.1	8.8	1.5	0.5	0.8	ND(.5)	10
	WP	1	IND.	1.2	ND(.2)	ND*(.3)	0.8	7.9	0.61	ND*(.2)	0.4	ND(.5)	7
	WP	1	IND.	1.3	ND(.2)	0.8	2.1	11	0.74	ND*(.2)	1	ND(.5)	7.1
	WP	1	IND.	1.3	ND(.2)	ND*(.3)	1	5.5	0.65	ND*(.2)	ND*(.3)	ND(.5)	4.3
	YP	1	IND.	1.1	ND(.2)	0.6	0.4	7.1	1.3	0.3	0.4	ND(.5)	6
	YP	1	IND.	1.3	ND(.2)	0.7	0.5	7.9	1.4	ND*(.2)	ND*(.3)	ND(.5)	5
	YP	3	COMP.	ND*(1.0)	ND(.2)	0.6	ND*(.2)	5	1.2	ND*(.2)	ND*(.3)	ND(.5)	5.2
	LMB	1	IND.	ND*(1.0)	ND(.2)	0.7	ND*(.2)	4.8	1	ND*(.2)	ND*(.3)	ND(.5)	4.4
	SMB	1	IND.	ND*(1.0)	ND(.2)	0.4	0.2	3.4	2.4	ND*(.2)	0.6	ND(.5)	4.6
	SMB	1	IND.	ND*(1.0)	ND(.2)	0.5	ND*(.2)	5	2.1	ND*(.2)	0.4	ND(.5)	3.6
	SMB	3	COMP.	ND*(1.0)	ND(.2)	1.1	0.3	8.2	1.8	ND*(.2)	0.5	ND(.5)	4.4
AVERAGE				**1**	**ND**	**0.5**	**0.6**	**6.5**	**1.4**	**0.15**	**0.4**	**ND**	**6**
RANGE				**0.5–2**	**NC**	**0.15–1.1**	**0.1–2.1**	**3.4–11**	**0.61–2.4**	**0.1–0.5**	**0.2–1**	**NC**	**3.6–10**
S. WATUPPA POND	SMB	1	IND.	ND*(1.0)	ND(.2)	ND(.3)	**86	8.6	0.5	ND*(.2)	**89	6	**58
n = 9	SMB	1	IND.	ND*(1.0)	ND(.2)	ND(.3)	0.7	2.2	0.48	ND*(.2)	1.7	0.5	3.1
	SMB	1	IND.	ND*(1.0)	ND(.2)	ND(.3)	4.5	2.8	0.34	ND*(.2)	5.4	2.9	6.4
	SMB	1	IND.	ND*(1.0)	ND(.2)	ND(.3)	18	3.2	0.5	ND*(.2)	24	3	16
	B	2	COMP.	ND*(1.0)	ND(.2)	ND(.3)	3.9	3.3	0.12	0.7	7.5	2.5	8.1
	WS	2	COMP.	ND*(1.0)	ND(.2)	ND(.3)	2.4	3.9	0.02	0.9	3.6	0.8	6.8
	P	1	IND.	1.2	ND(.2)	ND(.3)	3.2	4.2	0.07	0.6	4.5	2.6	7
	YP	5	COMP.	1	ND(.2)	ND(.3)	1	2.3	0.21	2.7	1.9	0.6	5.3
	WP	5	COMP.	1.2	ND(.2)	ND(.3)	2.3	5.2	0.23	0.5	2.3	ND*(.5)	6.5
AVERAGE				**0.7**	**ND**	**ND**	**4.5**	**4**	**0.3**	**0.6**	**6.4**	**2.1**	**7.4**
RANGE				**0.5–1.2**	**NC**	**NC**	**0.7–18**	**2.2–8.6**	**0.02–0.5**	**0.1–2.7**	**1.7–24**	**0.25–6**	**3.1–16**

Table N-2
Inorganics in Whole Fish Tissues from Lacustrine Systems
In Massachusetts (1)

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

WATERBODY	FISH CODE (2)	SAMPLE POPULATION	TYPE OF SAMPLE (3)	INORGANIC ANALYTES (ug/g wet weight tissue) * (4,5)									
				Al	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
DOROTHY POND	C	1	IND.	2.1	ND(.2)	ND (.3)	1.3	16	0.06	0.4	0.8	ND(.5)	10
n = 8	WP	5	COMP.	ND*(1)	ND(.2)	ND (.3)	1.6	11	0.24	0.4	0.6	ND(.5)	5.3
	YP	5	COMP.	1.6	ND(.2)	ND (.3)	4.8	4.5	0.12	0.8	1.3	ND(.5)	8.4
	WS	3	COMP.	ND*(1)	ND(.2)	ND (.3)	1.3	10	0.08	0.8	3.6	ND(.5)	11
	YB	2	COMP.	1.3	ND(.2)	ND (.3)	0.4	4.5	0.08	0.4	ND*(.3)	ND(.5)	15
	CP	1	IND.	ND*(.3)	ND(.2)	ND (.3)	1.2	2.3	0.16	0.8	1.3	ND(.5)	3.4
	LMB	1	IND.	1.3	ND(.2)	ND (.3)	1.2	3.3	0.12	0.8	ND*(.3)	ND(.5)	4.3
	LMB	3	COMP.	ND*(1)	ND(.2)	ND (.3)	0.2	1.8	0.16	2.7	2.7	ND(.5)	4.6
AVERAGE				**1.1**	**ND**	**ND**	**1.5**	**6.7**	**0.13**	**0.9**	**1.3**	**ND**	**7.8**
RANGE				**0.5–2.1**	**NC**	**NC**	**0.2–4.8**	**1.8~16**	**0.06~0.24**	**0.4–2.7**	**0.15–3.6**	**NC**	**3.4–15**
INDIAN LAKE	C	1	IND.	ND(1)	ND(.2)	ND(.3)	3.1	11	0.06	0.4	ND*(.3)	ND(.5)	9
n = 5	C	1	IND.	ND(1)	ND(.2)	ND(.3)	1.2	31	0.05	ND*(.2)	ND*(.3)	ND(.5)	9
	C	1	IND.	ND(1)	ND(.2)	ND(.3)	6.1	29	0.05	0.4	0.9	ND(.5)	7.6
	C	1	IND.	ND(1)	ND(.2)	ND(.3)	1.8	4.1	0.04	0.5	0.4	ND(.5)	6.4
	C	1	IND.	ND(1)	ND(.2)	ND(.3)	9.2	4.5	0.03	0.3	1.7	ND(.5)	7
AVERAGE				**ND**	**ND**	**ND**	**4.3**	**15.9**	**0.05**	**0.3**	**0.7**	**ND**	**7.8**
RANGE				**NC**	**NC**	**NC**	**1.2–9.2**	**4.1–31**	**0.03–.06**	**0.1–0.5**	**0.15–1.7**	**NC**	**6.4–9**
AVERAGE				0.9	ND	0.5	2.3	7.3	0.6	0.48	2.1	2.1	7
STANDARD ERROR				0.51	NC	0.31	3.45	6.61	0.72	0.62	4.29	1.84	3.03
SAMPLE SIZE				29	NC	12	33	34	34	34	33	9	33

NOTES:

(1) Data obtained from Massachusetts Division of Water Pollution Control ([MADWPC], 1988b; 1989a; 1990).

(2) CODE:
B = bluegill (Lepomis macrochirus)
C = carp (Cyprinus carpio)
CP = chain pickerel (Esox niger)
LMB = largemouth bass (Micropterus salmoides)
P = pumkinseed (Lepomis gibbosus)
SMB = smallmouth bass (Micropterus dolomieui)
WS = white sucker (Catostomus commersoni)
WP = white perch (Morone americana)
YB = yellow bullhead (Ictalurus nebulosus)
YP = yellow perch (Perca flavescens)

(3) IND. = Individual COMP. = Composite

(4) NC = Not Calculated
ND = *Not Detected (detection limit is presented in the parentheses).*
ND* = Non-detect was treated as a value one-half its detection limit (listed in parentheses) for calculation of the average and is represented in the lower limit of the range.
** = Outlier value was not used in calculating the average or in determining the range.

(5) When an analyte was undetected in all fish from a given waterbody, these data were not included in the summary table statistics calculation.

TABLE N-3
Pesticides / PCBs In Fish Tissue from
Lacustrine Systems In Massachusetts (1)

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

				Pesticides/PCBs (ug/g wet weight) (4)		
WATERBODY	FISH CODE (2)	SAMPLE POPULATION	SAMPLE TYPE (3)	DDE	AROCLOR 1254	AROCLOR 1260
ECHO LAKE	YP	1	IND.	0.015	NA	NA
n = 13	WP	1	IND.	0.033	NA	NA
	CP	1	IND.	0.02	NA	NA
	CP	1	IND.	0.013	NA	NA
	CP	1	IND.	0.014	NA	NA
	YP	1	IND.	0.016	NA	NA
	YP	1	IND.	0.011	NA	NA
	YP	1	IND.	0.029	NA	NA
	YP	1	IND.	0.023	NA	NA
	WP	1	IND.	0.018	NA	NA
	WP	1	IND.	0.035	NA	NA
	WP	1	IND.	0.017	NA	NA
	CP	1	IND.	0.01	NA	NA
AVERAGE				0.02	NC	NC
RANGE				0.01–0.035	NC	NC
WALDEN POND	SMB	1	IND.	0.02	0.048	ND(0.036)
n = 4	SMB	1	IND.	0.046	0.053	ND(0.036)
	SMB	1	IND.	0.052	0.056	ND(0.036)
	LMB	1	IND.	0.021	0.056	ND(0.036)
AVERAGE				0.035	0.053	ND
RANGE				0.021–0.052	0.048–0.056	NC
COPICUT RIV.RES.	SMB	1	IND.	NA	ND*(0.040)	NA
(River Mile 2.6)	SMB	1	IND.	NA	0.15	NA
n = 7	SMB	1	IND.	NA	0.07	NA
	CP	1	IND.	NA	ND*(0.040)	NA
	CP	1	IND.	NA	ND*(0.040)	NA
	YP	1	IND.	NA	ND*(0.040)	NA
	YP	3	COMP.	NA	ND*(0.040)	NA
AVERAGE				NC	0.046	NC
RANGE				NC	0.02–0.15	NC
N. WATUPPA	CP	1	IND.	NA	ND*(0.040)	ND*(0.036)
n = 12	CP	1	IND.	NA	ND*(0.040)	0.051
	WP	1	IND.	NA	0.14	ND*(0.036)

TABLE N-3

Pesticides / PCBs In Fish Tissue from

Lacustrine Systems In Massachusetts (1)

Remedial Investigation Addendum Report

Feasibility Study For Group 1A Sites

Fort Devens, MA

				Pesticides/PCBs (ug/g wet weight) (4)		
WATERBODY	FISH CODE (2)	SAMPLE POPULATION	SAMPLE TYPE (3)	DDE	AROCLOR 1254	AROCLOR 1260
N. WATUPPA	WP	1	IND.	NA	0.15	ND*(0.036)
(cont.')	WP	1	IND.	NA	0.26	ND*(0.036)
	YP	1	IND.	NA	0.12	ND*(0.036)
	YP	1	IND.	NA	ND*(0.040)	ND*(0.036)
	YP	3	COMP.	NA	ND*(0.040)	ND*(0.036)
	LMB	1	IND.	NA	ND*(0.040)	ND*(0.036)
	SMB	1	IND.	NA	ND*(0.040)	ND*(0.036)
	SMB	1	IND.	NA	0.055	ND*(0.036)
	SMB	3	COMP.	NA	0.056	ND*(0.036)
AVERAGE				**NC**	**0.075**	**0.024**
RANGE				**NC**	**0.02-0.26**	**0.018-0.051**
S. WATUPPA	SMB	1	IND.	NA	0.12	ND*(0.036)
n = 9	SMB	1	IND.	NA	ND*(0.040)	ND*(0.036)
	SMB	1	IND.	NA	ND*(0.040)	ND*(0.036)
	SMB	1	IND.	NA	ND*(0.040)	ND*(0.036)
	B	2	COMP.	NA	ND*(0.040)	ND*(0.036)
	WS	2	COMP.	NA	ND*(0.040)	ND*(0.036)
	P	1	IND.	NA	ND*(0.040)	ND*(0.036)
	YP	5	COMP.	NA	ND*(0.040)	ND*(0.036)
	WP	5	COMP.	NA	ND*(0.040)	0.064
AVERAGE				**NC**	**0.031**	**0.023**
RANGE				**NC**	**0.02-0.12**	**0.18-0.064**
DOROTHY POND	C	1	IND.	NA	ND(0.040)	0.73
n = 8	WP	5	COMP.	NA	ND(0.040)	0.015
	YP	5	COMP.	NA	ND(0.040)	ND*(0.036)
	WS	3	COMP.	NA	ND(0.040)	0.21
	YB	2	COMP.	NA	ND(0.040)	ND*(0.036)
	CP	1	IND.	NA	ND(0.040)	ND*(0.036)
	LMB	1	IND.	NA	ND(0.040)	ND*(0.036)
	LMB	3	COMP.	NA	ND(0.040)	ND*(0.036)
AVERAGE				**NC**	**ND**	**0.131**
RANGE				**NC**	**NC**	**0.018-0.73**

TABLE N-3

Pesticides / PCBs In Fish Tissue from

Lacustrine Systems In Massachusetts (1)

Remedial Investigation Addendum Report

Feasibility Study For Group 1A Sites

Fort Devens, MA

				Pesticides/PCBs (ug/g wet weight) (4)		
WATERBODY	**FISH CODE (2)**	**SAMPLE POPULATION**	**SAMPLE TYPE (3)**	**DDE**	**AROCLOR 1254**	**AROCLOR 1260**
INDIAN LAKE	C	1	IND.	NA	NA	0.47
n = 5	C	1	IND.	NA	NA	0.92
	C	1	IND.	NA	NA	0.13
	C	1	IND.	NA	NA	ND*(0.036)
	C	1	IND.	NA	NA	ND*(0.036)
AVERAGE				**NC**	**NC**	**0.311**
RANGE				**NC**	**NC**	**0.018-0.92**
AVERAGE				**0.023**	**0.054**	**0.089**
STANDARD ERROR				**0.0121**	**0.061**	**0.206**
SAMPLE SIZE				**17**	**29**	**34**

(1) Source: Massachusetts DEP Division of Water Pollution Control (MADWPC), 1988a; 1989a; 1989b; 1990; 1991.

(2) FISH CODE:

B = bluegill (Lepomus macrochirus)
C = carp (Cyprinus carpio)
CP = chain pickerel (Esox niger)
LMB = largemouth bass (Micropterus salmoides)
P = pumpkinseed (Lepomus gibbosus)
SMB = smallmouth bass (Micropterus dolomieui)
WP = white perch (Morone americana)
WS = white sucker (Catastomus commersoni)
YP = yellow perch (Perca flavescens)

(3) IND. = Individual
COMP. = Composite

(4) NA = Not Analyzed; NC = Not Calculated.
ND = Not Detected (detection limit presented in parentheses).
ND* = Non-detect was treated as a value one-half its detection limit (listed in the parentheses) for calculation of the average and is represented in the lower limit of the range.

Table N-4

Fish Tissue Concentrations: Regional and National Databases

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

ANALYTE	MADWPC [a]			USFWS [c]		
(mg/kg wet weight)	AVERAGE	95% CI [b]	MAXIMUM	AVERAGE [d]	85th % [e]	MAXIMUM
ORGANICS						
AROCLOR 1254	0.054	0.031-0.077	0.26	0.21	NA	4.0
AROCLOR 1260	0.091	0.022-0.160	0.92	0.15	NA	2.3
DDD	NA	NA	NA	0.06	NA	2.55
DDE	0.023	0.017-0.029	0.052	0.19	NA	4.74
DDT	NA	NA	NA	0.03	NA	1.79
INORGANICS						
ALUMINUM	0.9	0.71-1.09	2.1	NA	NA	NA
ARSENIC	NA	NA	NA	0.14	0.27	1.5
BARIUM	NA	NA	NA	NA	NA	NA
CADMIUM	NA	NA	NA	0.03	0.05	0.22
CHROMIUM	0.5	0.30-0.70	1.1	NA	NA	NA
COPPER	2.3	1.12-3.48	18	0.65	1	23.1
IRON	7.3	5.08-9.52	31	NA	NA	NA
LEAD	2.1	0.71-3.49	6	0.11	0.22	4.88
MANGANESE	0.48	0.27-0.69	2.7	NA	NA	NA
MERCURY	0.6	0.36-0.84	2.4	0.1	0.17	0.37
NICKEL	2.1	0.64-3.56	24	NA	NA	NA
SELENIUM	NA	NA	NA	0.42	0.73	2.3
ZINC	7	5.97-8.03	16	21.7	34.2	118.4

NA = Not Available.

[a] Data obtained from Massachusetts Division of Water Pollution Control (MADWPC, 1988a; 1988b; 1989a; 1989b; 1990; 1991).

[b] 95% CI = Ninety-fifth percent confidence interval (alpha = 0.05) on the estimated average.

[c] United States Fish and Wildlife Service (USFWS, 1990a; 1990b).

[d] Geometric average calculation of USFWS.

[e] 85th % = Eighty-fifth percentile of the geometric station averages of USFWS (1990a; 1990b).

Table N-5

Inorganics in Whole Fish Tissues from Lacustrine Systems in Massachusetts Partitioned by Fish Trophic Level (1)

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

WATERBODY	FISH CODE (2)	SAMPLE POPULATION	SAMPLE TYPE (3)	INORGANIC ANALYTES (mg/kg wet weight tissue) * (4) Al	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
PRIMARY CONSUMERS (n=12)													
North Watuppa Pond	WP	1	IND.	1.2	ND(.2)	ND*(.3)	0.8	7.9	0.61	ND*(.2)	0.4	ND*(.5)	7
	WP	1	IND.	1.3	ND(.2)	0.8	2.1	11	0.74	ND*(.2)	1	ND*(.5)	7.1
	WP	1	IND.	1.3	ND(.2)	ND*(.3)	1	5.5	0.65	ND*(.2)	ND*(.3)	ND*(.5)	4.3
	YP	1	IND.	1.1	ND(.2)	0.6	0.4	7.1	1.3	0.3	0.4	ND*(.5)	6
	YP	1	IND.	1.3	ND(.2)	0.7	0.5	7.9	1.4	ND*(.2)	ND*(.3)	ND*(.5)	5
	YP	3	COMP.	ND*(1.0)	ND(.2)	0.6	ND*(.2)	5	1.2	ND*(.2)	ND*(.3)	ND*(.5)	5.2
South Watuppa Pond	P	1	IND.	1.2	ND(.2)	ND*(.3)	3.2	4.2	0.07	0.6	4.5	2.6	7
	B	2	COMP.	ND*(1.0)	ND(.2)	ND(.3)	3.9	3.3	0.12	0.7	7.5	2.5	8.1
	YP	5	COMP.	1	ND(.2)	ND*(.3)	1	2.3	0.21	2.7	1.9	0.6	5.3
	WP	5	COMP.	1.2	ND(.2)	ND*(.3)	2.3	5.2	0.23	0.5	2.3	ND*(.5)	6.5
Dorothy Pond	WP	5	COMP.	ND*(1)	ND(.2)	ND*(.3)	1.6	11	0.24	0.4	0.6	ND*(.5)	5.3
	YP	5	COMP.	1.6	ND(.2)	ND*(.3)	4.8	4.5	0.12	0.8	1.3	ND*(.5)	8.4
AVERAGE				**1.06**	**ND**	**0.33**	**1.81**	**6.24**	**0.57**	**0.54**	**1.70**	**0.66**	**6.27**
RANGE				**0.5-1.6**	**ND**	**0.15-0.8**	**0.1-4.8**	**2.3-11**	**0.07-1.4**	**0.1-2.7**	**0.15-7.5**	**0.25-2.6**	**4.3-8.4**
STANDARD ERROR				**0.35**	**NC**	**0.25**	**1.43**	**2.68**	**0.47**	**0.70**	**2.13**	**0.85**	**1.23**
BOTTOM FEEDERS (n=9)													
South Watuppa Pond	WS	2	COMP.	ND*(1.0)	ND(.2)	ND(.3)	2.4	3.9	0.02	0.9	3.6	0.8	6.8
Dorothy Pond	C	1	IND.	2.1	ND(.2)	ND (.3)	1.3	16	0.06	0.4	0.8	ND*(.5)	10
	WS	3	COMP.	ND*(1)	ND(.2)	ND (.3)	1.3	10	0.08	0.8	3.6	ND*(.5)	11
	YB	2	COMP.	1.3	ND(.2)	ND (.3)	0.4	4.5	0.08	0.4	ND*(.3)	ND*(.5)	15
Indian Lake	C	1	IND.	ND*(1)	ND(.2)	ND(.3)	3.1	11	0.06	0.4	ND*(.3)	ND*(.5)	9
	C	1	IND.	ND*(1)	ND(.2)	ND(.3)	1.2	31	0.05	ND*(.2)	ND*(.3)	ND*(.5)	9
	C	1	IND.	ND*(1)	ND(.2)	ND(.3)	6.1	29	0.05	0.4	0.9	ND*(.5)	7.6
	C	1	IND.	ND*(1)	ND(.2)	ND(.3)	1.8	4.1	0.04	0.5	0.4	ND*(.5)	6.4
	C	1	IND.	ND*(1)	ND(.2)	ND(.3)	9.2	4.5	0.03	0.3	1.7	ND*(.5)	7
AVERAGE				**0.77**	**ND**	**ND**	**2.98**	**12.67**	**0.05**	**0.47**	**1.27**	**0.31**	**9.09**
RANGE				**0.5-2.1**	**ND**	**ND**	**0.4-9.2**	**3.9-31**	**0.02-0.08**	**0.1-0.9**	**0.15-3.6**	**0.25-0.8**	**6.4-15**
STANDARD ERROR				**0.53**	**NC**	**NC**	**2.70**	**10.04**	**0.02**	**0.23**	**1.33**	**0.17**	**2.55**

Table N-5

Inorganics in Whole Fish Tissues from Lacustrine Systems in Massachusetts Partitioned by Fish Trophic Level (1)

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

WATERBODY	FISH CODE (2)	SAMPLE POPULATION	SAMPLE TYPE (3)	INORGANIC ANALYTES (mg/kg wet weight tissue) * (4) Al	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
SECONDARY/TERTIARY FEEDERS (n=13)**													
North Watuppa Pond	LMB	1	IND.	ND*(1.0)	ND(.2)	0.7	ND*(.2)	4.8	1	ND*(.2)	ND*(.3)	ND*(.5)	4.4
	SMB	1	IND.	ND*(1.0)	ND(.2)	0.4	0.2	3.4	2.4	ND*(.2)	0.6	ND*(.5)	4.6
	SMB	1	IND.	ND*(1.0)	ND(.2)	0.5	ND*(.2)	5	2.1	ND*(.2)	0.4	ND*(.5)	3.6
	SMB	3	COMP.	ND*(1.0)	ND(.2)	1.1	0.3	8.2	1.8	ND*(.2)	0.5	ND*(.5)	4.4
	CP	1	IND.	2	ND(.2)	ND*(.3)	0.5	3.9	2.4	ND*(.2)	0.4	ND*(.5)	10
	CP	1	IND.	1.2	ND(.2)	ND*(.3)	1.1	8.8	1.5	0.5	0.8	ND*(.5)	10
South Watuppa Pond	SMB	1	IND.	ND*(1.0)	ND(.2)	ND*(.3)	**86	8.6	0.5	ND*(.2)	**89	6	**58
	SMB	1	IND.	ND*(1.0)	ND(.2)	ND*(.3)	0.7	2.2	0.48	ND*(.2)	1.7	0.5	3.1
	SMB	1	IND.	ND*(1.0)	ND(.2)	ND*(.3)	4.5	2.8	0.34	ND*(.2)	5.4	2.9	6.4
	SMB	1	IND.	ND*(1.0)	ND(.2)	ND*(.3)	18	3.2	0.5	ND*(.2)	24	3	16
Dorothy Pond	CP	1	IND.	ND*(.3)	ND(.2)	ND*(.3)	1.2	2.3	0.16	0.8	1.3	ND*(.5)	3.4
	LMB	1	IND.	1.3	ND(.2)	ND*(.3)	1.2	3.3	0.12	0.8	ND*(.3)	ND*(.5)	4.3
	LMB	3	COMP.	ND*(1)	ND(.2)	ND*(.3)	0.2	1.8	0.16	2.7	2.7	ND*(.5)	4.6
AVERAGE				**0.70**	**ND**	**0.31**	**2.34**	**4.48**	**1.04**	**0.44**	**3.18**	**1.13**	**6.23**
RANGE				**0.15-2**	**ND**	**0.15-1.1**	**0.1-18**	**1.8-8.8**	**0.12-2.4**	**0.1-2.7**	**0.15-24**	**0.25-6**	**3.1-16**
STANDARD ERROR				**0.48**	**NC**	**0.28**	**4.93**	**2.39**	**0.85**	**0.70**	**6.44**	**1.70**	**3.70**

NOTES:

(1) Data obtained from Massachusetts Division of Water Pollution Control ([MADWPC], 1988b; 1989a; 1990).

(2) CODE:
B = bluegill (*Lepomis macrochirus*)
C = carp (Cyprinus carpio)
CP = chain pickerel (Esox niger)
LMB = largemouth bass (Micropterus salmoides)
P = pumkinseed (Lepomis gibbosus)
SMB = smallmouth bass (Micropterus dolomieui)
WS = white sucker (Catostomus commersoni)
WP = white perch (Morone americana)
YB = yellow bullhead (Ictalurus nebulosus)
YP = yellow perch (Perca flavescens)

(3) IND. = Individual analyzed
COMP. = Composite analyzed

(4) When an analyte was undetected in all fish from a given waterbody, these data were not included in the summary statistics calculations.

NC = Not Calculated
ND = Not Detected (detection limit is presented in the parentheses).
ND* = Non-detect was treated as a value one-half its detection limit (listed in parentheses) for calculation of the average and is represented in the lower limit of the range.
** = Outlier value was not used in calculating the average.

Table N-6

Comparison of Plow Shop Pond (PSP)

Bluegill Whole Body Tissue Concentrations to Regional and National Databases [a]

Remedial Investigation Addendum Report

Feasibility Study for Group 1A Sites

Fort Devens, MA

ANALYTE (ug/g wet weight tissue)	PSP AVERAGE [b]	MADWPC AVERAGE	PSP AVG. EXCEEDS MADWPC	PSP MAXIMUM [b]	USFWS MAXIMUM OR 85th% [c]	PSP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
DDE	0.013	0.023	N	0.029	4.74	N
INORGANICS						
ALUMINUM	2.6	0.9	Y	4.5	NA	NA
ARSENIC	0.33	NA	NA	1.3	0.27	Y
BARIUM	2.8	NA	NA	4.4	NA	NA
CHROMIUM	0.66	0.5	Y	0.93	NA	NA
COBALT	0.11	NA	NA	0.16	NA	NA
COPPER	0.51	2.3	N	0.6	1	N
IRON	80.0	7.3	Y	130	NA	NA
LEAD	0.078	2.1	N	0.16	0.22	N
MANGANESE	63	0.48	Y	94.7	NA	NA
MERCURY	0.37	0.6	N	0.54	0.17	Y
SELENIUM	0.55	NA	NA	0.67	0.73	N
THALLIUM	0.06	NA	NA	0.1	NA	NA
ZINC	25	7	Y	29.6	34.2	N

NOTES:

NA = Not Available.

[a] See Table N-4 for data of Massachusetts Division of Water Pollution Control (MADWPC) and United States Fish and Wildlife Service (USFWS).

[b] Analytical data presented in Table 7-4.

[c] Use of maximum or 85th % is described in Appendix N, Section 2.2.

Table N-7

Comparison of Plow Shop Pond (PSP)

Brown Bullhead Whole Body Tissue Concentration to Regional and National Databases [a]

Remedial Investigation Addendum Report

Feasibility Study for Group 1A Sites

Fort Devens, MA

ANALYTE (ug/g wet weight tissue)	PSP AVERAGE [b]	MADWPC AVERAGE	PSP AVG. EXCEEDS MADWPC	PSP MAXIMUM [b]	USFWS MAXIMUM OR 85th % [c]	PSP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
DDD	0.006	NA	NA	0.012	2.55	N
DDE	0.017	0.023	N	0.033	4.74	N
INORGANICS						
ALUMINUM	1.66	0.9	Y	2.9	NA	NA
ARSENIC	0.127	NA	NA	0.3	0.27	Y
BARIUM	0.792	NA	NA	1.3	NA	NA
CHROMIUM	0.416	0.5	N	0.99	NA	NA
COBALT	0.074	NA	NA	0.17	NA	NA
COPPER	0.758	2.3	N	1.3	1	Y
IRON	39.02	7.3	Y	71.2	NA	NA
LEAD	0.076	2.1	N	0.18	0.22	N
MANGANESE	9.46	0.48	Y	16	NA	NA
MERCURY	0.282	0.6	N	0.4	0.17	Y
SELENIUM	0.274	NA	NA	0.31	0.73	N
ZINC	16.28	7	Y	22.3	34.2	N

NOTES:

NA = Not Available.

[a] See Table N-4 for data of Massachusetts Division of Water Pollution Control (MADWPC) and the United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7-4.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-8
Comparison of Plow Shop Pond (PSP)
Largemouth Bass Whole Body Tissue Concentration to Regional and National Databases [a]

Remedial Investigation Addendum Report
Feasibility Study for Group 1A Sites
Fort Devens, MA

ANALYTE (ug/g wet weight tissue)	PSP AVERAGE [b]	MADWPC AVERAGE	PSP AVG. EXCEEDS MADWPC	PSP MAXIMUM [b]	USFWS MAXIMUM OR 85th % [c]	PSP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
AROCLOR 1260	0.137	0.091	Y	0.33	2.3	N
DDD	0.046	NA	NA	0.11	2.55	N
DDE	0.174	0.023	Y	0.416	4.74	N
DDT	0.006	NA	NA	0.012	1.79	N
INORGANICS						
ALUMINUM	1.39	0.9	Y	2.9	NA	NA
BARIUM	0.58	NA	NA	0.99	NA	NA
CADMIUM	0.044	NA	NA	0.09	0.05	Y
CHROMIUM	0.432	0.5	N	0.65	NA	NA
COPPER	0.576	2.3	N	0.9	1	N
IRON	16.3	7.3	Y	24.6	NA	NA
MANGANESE	6.34	0.48	Y	8.8	NA	NA
MERCURY	1.38	0.6	Y	2.7	0.17	Y
SELENIUM	0.378	NA	NA	0.54	0.73	N
ZINC	16.36	7	Y	18.9	34.2	N

NOTES:

NA = Not Available.

[a] See Table N-4 for data of Massachusetts Division of Water Pollution Control (MADWPC) and United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7-4.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-9

Comparison of Plow Shop Pond (PSP)

All Whole Fish Body Tissue Concentration Data to Regional and National Databases [a]

Remedial Investigation Addendum Report

Feasibility Study for Group 1A Sites

Fort Devens, MA

ANALYTE (ug/g wet weight tissue)	PSP AVERAGE [b]	MADWPC AVERAGE	PSP AVG. EXCEEDS MADWPC	PSP MAXIMUM [b]	USFWS MAXIMUM OR 85th% [c]	PSP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
AROCLOR 1260	0.062	0.091	N	0.33	2.3	N
DDD	0.019	NA	NA	0.11	2.55	N
DDE	0.068	0.023	Y	0.416	4.74	N
DDT	0.006	NA	NA	0.012	1.79	N
INORGANICS						
ALUMINUM	1.88	0.9	Y	4.5	NA	NA
ARSENIC	0.19	NA	NA	1.3	0.27	Y
BARIUM	1.34	NA	NA	4.4	NA	NA
CADMIUM	0.04	NA	NA	0.09	0.05	Y
CHROMIUM	0.5	0.5	N	0.99	NA	NA
COBALT	0.08	NA	NA	0.17	NA	NA
COPPER	0.61	2.3	N	1.3	1	Y
IRON	45.01	7.3	Y	130	NA	NA
LEAD	0.07	2.1	N	0.18	0.22	N
MANGANESE	26.33	0.48	Y	94.7	NA	NA
MERCURY	0.68	0.6	Y	2.7	0.17	Y
SELENIUM	0.4	NA	NA	0.67	0.73	N
THALLIUM	0.05	NA	NA	0.1	NA	NA
ZINC	19.22	7	Y	29.6	34.2	N

NOTES:

NA = Not Available.

[a] See Table N-4 for Data of Massachusetts Division of Water Pollution Control (MADWPC) and the United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7-4.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-10
Fish Sampling Results for Selected Analytical Parameters
Plow Shop Pond

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Fort Devens, MA

WHOLE BODY FISH TISSUE CONCENTRATIONS [a]							LIPID-NORMALIZED CONCENTRATIONS [b]	
SPECIES	SAMPLE ID	DDE (ug/kg)	MERCURY (ug/kg)	% LIPIDS	WEIGHT (g)	% SOLIDS	DDE (ug/kg lipid)	MECURY (ug/kg lipid)
BLUEGILL	PSP02W	4.8	400	0.28	90	24	0.17	14.29
BLUEGILL	PSP03W	29	190	1.03	137	25	0.28	1.84
BLUEGILL	PSP04W	21	540	0.46	92	27.5	0.46	11.74
BLUEGILL	PSP10W	4.8	470	0.16	100	28.3	0.30	29.38
BLUEGILL	PSP11W	5	240	0.37	99	26.6	0.14	6.49
BULLHEAD	PSP05W	15	360	0.62	166	20.4	0.24	5.81
BULLHEAD	PSP06W	4.85	280	0.72	95	23.6	0.07	3.89
BULLHEAD	PSP12W	17	400	0.98	142	22	0.17	4.08
BULLHEAD	PSP22W	33	280	1.56	111	23.2	0.21	1.79
BULLHEAD	PSP23W	14	90	0.48	419	18.8	0.29	1.88
BASS	PSP07WRE	150	2200	2.49	3480	27.3	0.60	8.84
BASS	PSP17WRE	416	2700	3.27	3440	34	1.27	8.26
BASS	PSP18WRE	82	650	2.45	1280	26.1	0.33	2.65
BASS	PSP19WRE	84	650	1.25	972	25.5	0.67	5.20
BASS	PSP20WRE	140	720	1.79	687	24.4	0.78	4.02

Notes:
[a] Non-detected values converted to half the detection level.
[b] Whole body concentrations lipid-normalized by dividing by the % lipids (kg lipids/kg).

Table N–11
Comparison of Cold Spring Brook Pond (CSBP)
Pumpkinseed Whole Body Tissue Concentrations to Regional and National Databases [a]

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Fort Devens, MA

ANALYTE (ug/g wet weight tissue)	CSBP AVERAGE [b]	MADWPC AVERAGE	CSBP AVG. EXCEEDS MADWPC	CSBP MAXIMUM [b]	USFWS MAXIMUM OR 85th% [c]	CSBP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
DDD	0.12	NA	NA	0.23	2.55	N
DDE	0.083	0.023	Y	0.17	4.74	N
INORGANICS						
ARSENIC	0.15	NA	NA	0.27	0.27	N
BARIUM	0.47	NA	NA	0.64	NA	NA
CHROMIUM	0.30	0.5	N	0.33	NA	NA
COBALT	0.12	NA	NA	0.2	NA	NA
COPPER	0.39	2.3	N	0.41	1	N
IRON	32.9	7.3	Y	41.5	NA	NA
MANGANESE	10.0	0.48	Y	12	NA	NA
MERCURY	0.16	0.6	N	0.24	0.17	Y
SELENIUM	0.25	NA	NA	0.45	0.73	N
ZINC	21.0	7	Y	24.1	34.2	N

NOTES:

NA = Not Available.

[a] See Table N–4 for data of Massachusetts Division of Water Pollution Control (MADWPC) and the United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7–23.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-12

Comparison of Cold Spring Brook Pond (CSBP)

Bullhead Whole Body Tissue Concentrations to Regional and National Databases [a]

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ANALYTE (ug/g wet weight tissue)	CSBP AVERAGE [b]	MADWPC AVERAGE	CSBP AVG. EXCEEDS MADWPC	CSBP MAXIMUM [b]	USFWS MAXIMUM OR 85th% [c]	CSBP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
AROCLOR 1254	0.034	0.54	N	0.052	4	N
DDD	0.17	NA	NA	0.34	2.55	N
DDE	0.085	0.023	**Y**	0.15	4.74	N
INORGANICS						
BARIUM	0.26	NA	NA	0.41	NA	NA
CHROMIUM	0.25	0.5	N	0.43	NA	NA
COBALT	0.11	NA	NA	0.16	NA	NA
COPPER	0.55	2.3	N	0.68	1	N
IRON	28.9	7.3	**Y**	35.9	NA	NA
MANGANESE	7.1	0.48	**Y**	10.4	NA	NA
MERCURY	0.12	0.6	N	0.14	0.17	N
SELENIUM	0.28	NA	NA	0.41	0.73	N
ZINC	15.5	7	**Y**	21.4	34.2	N

NOTES:

NA = Not Available.

[a] See Table N-4 for data of Massachusetts Division of Water Pollution Control (MADWPC) and the United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7-23.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-13

Comparison of Cold Spring Brook Pond (CSBP)

Chain Pickerel Whole Body Tissue Concentrations to Regional and National Databases [a]

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Fort Devens, MA

ANALYTE (ug/g wet weight tissue)	CSBP AVERAGE [b]	MADWPC AVERAGE	CSBP AVG. EXCEED MADWPC	CSBP MAXIMUM [b]	USFWS MAXIMUM OR 85th% [c]	CSBP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
DDD	0.088	NA	NA	0.16	2.55	N
DDE	0.079	0.023	Y	0.15	4.74	N
INORGANICS						
BARIUM	0.34	NA	NA	0.52	NA	NA
CHROMIUM	0.20	0.5	N	0.27	NA	NA
COPPER	0.58	2.3	N	0.67	1	N
IRON	13.4	7.3	Y	15.3	NA	NA
MANGANESE	9.6	0.48	Y	14.1	NA	NA
MERCURY	0.36	0.6	N	0.47	0.17	Y
SELENIUM	0.16	NA	NA	0.25	0.73	N
ZINC	43.4	7	Y	51.3	34.2	Y

NOTES:

NA = Not Available.

[a] See Table N-4 for data of Massachusetts Division of Water Pollution Control (MADWPC) and the United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7-23.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-14
Comparison of Cold Spring Brook Pond (CSBP)
All Whole Body Fish Tissue Concentration Data to Regional and National Databases [a]

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ANALYTE (ug/g wet weight tissue)	CSBP AVERAGE [b]	MADWPC AVERAGE	CSBP AVG. EXCEEDS MADWPC	CSBP MAXIMUM [b]	USFWS MAXIMUM OR 85th% [c]	CSBP MAX. EXCEEDS USFWS
PCBs/PESTICIDES						
AROCLOR 1254	0.028	0.054	N	0.052	4.0	N
DDD	0.12	NA	NA	0.34	2.55	N
DDE	0.082	0.023	Y	0.17	4.74	N
INORGANICS						
ARSENIC	0.10	NA	NA	0.27	0.27	N
BARIUM	0.36	NA	NA	0.64	NA	NA
CHROMIUM	0.25	0.5	N	0.43	NA	NA
COBALT	0.093	NA	NA	0.2	NA	NA
COPPER	0.51	2.3	N	0.68	1	N
IRON	25.1	7.3	Y	41.5	NA	NA
MANGANESE	8.9	0.48	Y	14.1	NA	NA
MERCURY	0.21	0.6	N	0.47	0.17	Y
SELENIUM	0.23	NA	NA	0.45	0.73	N
ZINC	26.6	7	Y	51.3	34.2	Y

NOTES:

NA = Not Available.

[a] See Table N-4 for Data of Massachusetts Division of Water Pollution Control (MADWPC) and the United States Fish and Wildlife Service (USFWS).

[b] Analytical data provided in Table 7-23.

[c] Use of maximum or 85th % described in Appendix N, Section 2.2.

Table N-15
Fish Sampling Results for Selected Analytical Parameters
Cold Spring Brook Pond

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		WHOLE BODY FISH TISSUE CONCENTRATIONS [a]					LIPID-NORMALIZED CONCENTRATIONS [b]	
SPECIES	SAMPLE ID:	DDE (ug/kg)	MERCURY (ug/kg)	% LIPIDS	WEIGHT (g)	% SOLIDS	DDE (ug/kg lipid)	MERCURY (ug/kg lipid)
PUMPKINSEED	CSB13W	58	150	0.89	39	26.3	0.65	1.69
PUMPKINSEED	CSB14W	22	240	0.58	52	25.9	0.38	4.14
PUMPKINSEED	CSB15W	170	80	2.1	38	26.7	0.81	0.38
BULLHEAD	CSB07W	150	90	4.16	31	28.6	0.36	0.22
BULLHEAD	CSB08W	73	140	3.17	31	22.4	0.23	0.44
BULLHEAD	CSB09W	31	130	0.79	41	22.2	0.39	1.65
PICKEREL	CSB01W	26	230	0.38	123	25.4	0.68	6.05
PICKEREL	CSB02W	61	470	1.5	367	23.4	0.41	3.13
PICKEREL	CSB03W	150	390	1.4	178	29.7	1.07	2.79

Notes:

[a] Non-detected values converted to half the SQL.

[b] Whole body concentrations lipid-normalized by dividing by the % lipids (kg lipids/kg).

Table N-15
Fish Sampling Results for Selected Analytical Parameters
Cold Spring Brook Pond

Remedial Investigation Addendum Report
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		WHOLE BODY FISH TISSUE CONCENTRATIONS [a]					LIPID-NORMALIZED CONCENTRATIONS [b]	
SPECIES	SAMPLE ID:	DDE (ug/kg)	MERCURY (ug/kg)	% LIPIDS	WEIGHT (g)	% SOLIDS	DDE (ug/kg lipid)	MERCURY (ug/kg lipid)
PUMPKINSEED	CSB13W	58	150	0.89	39	26.3	0.65	1.69
PUMPKINSEED	CSB14W	22	240	0.58	52	25.9	0.38	4.14
PUMPKINSEED	CSB15W	170	80	2.1	38	26.7	0.81	0.38
BULLHEAD	CSB07W	150	90	4.16	31	28.6	0.36	0.22
BULLHEAD	CSB08W	73	140	3.17	31	22.4	0.23	0.44
BULLHEAD	CSB09W	31	130	0.79	41	22.2	0.39	1.65
PICKEREL	CSB01W	26	230	0.38	123	25.4	0.68	6.05
PICKEREL	CSB02W	61	470	1.5	367	23.4	0.41	3.13
PICKEREL	CSB03W	150	390	1.4	178	29.7	1.07	2.79

Notes:

[a] Non-detected values converted to half the SQL.

[b] Whole body concentrations lipid-normalized by dividing by the % lipids (kg lipids/kg).

TABLE N-16
Fish Length and Weight Summary
Plow Shop Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES		LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
AMERICAN EEL		550	NA	
	Maximum	550	NA	
	Minimum	550	NA	
	Average	550	NA	
	N=	1	0	
BLACK BULLHEAD [b]		281	290	
	Maximum	281	290	
	Minimum	281	290	
	Average	281	290	
	N=	1	1	
BLACK CRAPPIE		72	NA	
BLACK CRAPPIE		192	94	
	Maximum	192	94	
	Minimum	72	94	
	Average	152	94	
	N=	2	1	
BLUEGILL		79	NA	
BLUEGILL		83	13	
BLUEGILL		88	11	
BLUEGILL		89	NA	
BLUEGILL		92	15	
BLUEGILL		93	12	
BLUEGILL		94	NA	
BLUEGILL		98	13	
BLUEGILL		99	21	PSP - 11
BLUEGILL		100	18	
BLUEGILL		100	18	
BLUEGILL		103	15	
BLUEGILL		104	14	
BLUEGILL		105	25	
BLUEGILL		106	21	
BLUEGILL		106	25	
BLUEGILL		107	23	
BLUEGILL		107	9.0	
BLUEGILL		107	21	
BLUEGILL		107	21	
BLUEGILL		107	24	
BLUEGILL		108	26	
BLUEGILL		108	NA	
BLUEGILL		108	16	
BLUEGILL		110	25	
BLUEGILL		110	22	
BLUEGILL		110	21	
BLUEGILL		111	26	
BLUEGILL		112	27	
BLUEGILL		112	19	
BLUEGILL		112	24	
BLUEGILL		113	33	
BLUEGILL		113	22	
BLUEGILL		113	NA	
BLUEGILL		114	18	
BLUEGILL		114	29	
BLUEGILL		114	33	
BLUEGILL		116	26	
BLUEGILL		116	37	
BLUEGILL		117	30	

TABLE N-16
Fish Length and Weight Summary
Plow Shop Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES	LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
BLUEGILL	118	25	
BLUEGILL	118	28	
BLUEGILL	119	29	
BLUEGILL	119	37	
BLUEGILL	120	21	
BLUEGILL	123	NA	
BLUEGILL	123	43	
BLUEGILL	128	NA	
BLUEGILL	128	NA	
BLUEGILL	130	40	
BLUEGILL	131	NA	
BLUEGILL	132	43	
BLUEGILL	133	46	
BLUEGILL	134	43	
BLUEGILL	135	54	
BLUEGILL	136	NA	
BLUEGILL	140	43	
BLUEGILL	142	50	
BLUEGILL	142	47	
BLUEGILL	143	54	
BLUEGILL	143	60	
BLUEGILL	147	51	
BLUEGILL	148	65	
BLUEGILL	153	NA	
BLUEGILL	153	54	
BLUEGILL	153	60	
BLUEGILL	154	NA	
BLUEGILL	156	NA	
BLUEGILL	157	73	
BLUEGILL	158	78	
BLUEGILL	158	73	
BLUEGILL	158	71	
BLUEGILL	158	NA	
BLUEGILL	160	NA	
BLUEGILL	160	75	
BLUEGILL	162	78	
BLUEGILL	162	72	
BLUEGILL	163	79	
BLUEGILL	163	NA	
BLUEGILL	164	77	
BLUEGILL	164	NA	
BLUEGILL	164	NA	
BLUEGILL	164	NA	
BLUEGILL	165	NA	
BLUEGILL	166	94	
BLUEGILL	166	81	
BLUEGILL	167	85	
BLUEGILL	169	91	
BLUEGILL	169	93	
BLUEGILL	170	NA	
BLUEGILL	170	NA	
BLUEGILL	171	103	
BLUEGILL	171	NA	
BLUEGILL	171	NA	
BLUEGILL	172	92	
BLUEGILL	174	NA	
BLUEGILL	174	NA	
BLUEGILL	174	NA	
BLUEGILL	174	93	
BLUEGILL	175	NA	

TABLE N-16
Fish Length and Weight Summary
Plow Shop Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES	LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
BLUEGILL	175	86	
BLUEGILL	176	NA	
BLUEGILL	176	106	
BLUEGILL	176	98	
BLUEGILL	177	106	
BLUEGILL	177	99	
BLUEGILL	178	NA	
BLUEGILL	179	NA	
BLUEGILL	179	108	
BLUEGILL	180	NA	
BLUEGILL	180	92	PSP - 04
BLUEGILL	181	NA	
BLUEGILL	185	NA	
BLUEGILL	185	NA	
BLUEGILL	186	NA	
BLUEGILL	186	90	PSP - 02
BLUEGILL	187	NA	
BLUEGILL	188	122	
BLUEGILL	189	NA	
BLUEGILL	190	NA	
BLUEGILL	192	100	PSP - 10
BLUEGILL	196	137	PSP - 03
BLUEGILL	198	NA	
BLUEGILL	198	NA	
BLUEGILL	203	NA	
Maximum	203	137	
Minimum	79	9	
Average	143.5	50.6	
N=	125	83	
BROWN BULLHEAD	211	95	PSP - 06
BROWN BULLHEAD	232	166	PSP - 05
BROWN BULLHEAD	324	419	PSP - 23
BROWN BULLHEAD	224	142	PSP - 12
Maximum	324	419	
Minimum	211	95	
Average	247.8	205.5	
N=	4	4	
CHAIN PICKEREL	111	NA	
CHAIN PICKEREL	298	151	
CHAIN PICKEREL	327	NA	
CHAIN PICKEREL	328	193	
CHAIN PICKEREL	329	NA	
CHAIN PICKEREL	335	206	
CHAIN PICKEREL	349	NA	
CHAIN PICKEREL	353	NA	
CHAIN PICKEREL	362	143	
CHAIN PICKEREL	372	276	
CHAIN PICKEREL	373	283	
CHAIN PICKEREL	384	293	PSP - 13 [c]
CHAIN PICKEREL	389	349	PSP - 14 [c]
CHAIN PICKEREL	389	344	PSP - 09 [c]
CHAIN PICKEREL	393	329	PSP - 01 [c]

TABLE N-16
Fish Length and Weight Summary
Plow Shop Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES	LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
CHAIN PICKEREL	395	355	PSP - 16 [c]
CHAIN PICKEREL	400	387	PSP - 15 [c]
CHAIN PICKEREL	418	384	PSP - 08 [c]
Maximum	418	387	
Minimum	111	143	
Average	350.3	284.1	
N=	18	13	
GOLDEN SHINER	75	NA	
GOLDEN SHINER	83	NA	
GOLDEN SHINER	161	NA	
GOLDEN SHINER	196	92	
GOLDEN SHINER	198	NA	
GOLDEN SHINER	208	92	
GOLDEN SHINER	226	NA	
GOLDEN SHINER	228	143	
GOLDEN SHINER	231	NA	
GOLDEN SHINER	234	NA	
GOLDEN SHINER	243	176	
GOLDEN SHINER	248	NA	
GOLDEN SHINER	251	NA	
Maximum	251	176	
Minimum	75	92	
Average	198.6	125.8	
N=	13	4	
LARGEMOUTH BASS	71	NA	
LARGEMOUTH BASS	156	38	
LARGEMOUTH BASS	262	231	
LARGEMOUTH BASS	367	687	PSP - 20
LARGEMOUTH BASS	405	972	PSP - 19
LARGEMOUTH BASS	436	1280	PSP - 18
LARGEMOUTH BASS	532	3480	PSP - 07
LARGEMOUTH BASS	545	3440	PSP - 17
Maximum	545	3480	
Minimum	71	38	
Average	346.8	1446.9	
N=	8	7	
PUMPKINSEED	106	25	
PUMPKINSEED	108	19	
PUMPKINSEED	114	28	
PUMPKINSEED	124	NA	
PUMPKINSEED	137	34	
PUMPKINSEED	143	NA	
PUMPKINSEED	144	59	
PUMPKINSEED	148	56	
PUMPKINSEED	158	90	
PUMPKINSEED	163	86	
PUMPKINSEED	167	107	
PUMPKINSEED	169	104	
PUMPKINSEED	170	107	
PUMPKINSEED	174	110	
PUMPKINSEED	174	115	
PUMPKINSEED	176	115	
PUMPKINSEED	178	105	
Maximum	178	115	
Minimum	106	19	
Average	150.2	77.3	
N=	17	15	

TABLE N-16
Fish Length and Weight Summary
Plow Shop Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES	LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
WHITE PERCH	244	228	
Maximum	244	228	
Minimum	244	228	
Average	244.0	228.0	
N=	1	1	
YELLOW BULLHEAD	211	111	PSP - 22
YELLOW BULLHEAD	226	129	PSP - 21 [c]
Maximum	226	129	
Minimum	211	111	
Average	218.5	120.0	
N=	2	2	
YELLOW PERCH	211	107	
YELLOW PERCH	214	NA	
YELLOW PERCH	230	140	
YELLOW PERCH	239	NA	
YELLOW PERCH	240	166	
YELLOW PERCH	245	NA	
YELLOW PERCH	252	NA	
YELLOW PERCH	260	NA	
Maximum	260	166	
Minimum	211	107	
Average	236.4	137.7	
N=	8	3	

Notes:
[a] Fish were collected October 20 - 22, 1992. Weight data were not collected for all individuals.
[b] Although the black bullhead was identified in the field, this species is unusual in Massachusetts; the possibility of misidentification exists.
[c] These fish were collected but not analyzed for contaminant tissue burden.
NA = Not Available

TABLE N-17
Fish Length and Weight Summary
Cold Spring Brook Pond

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Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES		LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
AMERICAN EEL		650	NA	
	Maximum	650	NA	
	Minimum	650	NA	
	Average	650	NA	
	N=	1	0	
BLACK CRAPPIE		54	NA	
BLACK CRAPPIE		58	NA	
BLACK CRAPPIE		68	NA	
BLACK CRAPPIE		181	78	
BLACK CRAPPIE		181	72	
BLACK CRAPPIE		186	88	
	Maximum	186	88	
	Minimum	54	72	
	Average	121.3	79.3	
	N=	6	3	
CHAIN PICKEREL		210	44	
CHAIN PICKEREL		243	75	
CHAIN PICKEREL		290	123	CSBP - 01
CHAIN PICKEREL		330	178	CSBP - 03
CHAIN PICKEREL		342	228	CSBP - 04
CHAIN PICKEREL		382	291	CSBP - 05
CHAIN PICKEREL		398	367	CSBP - 02
CHAIN PICKEREL		398	418	CSBP - 06
	Maximum	398	418	
	Minimum	210	44	
	Average	324.1	215.5	
	N=	8	8	
GOLDEN SHINER		NA	NA	CSBP - 17 [b]
GOLDEN SHINER		NA	NA	CSBP - 16 [b]
GOLDEN SHINER		52	NA	
GOLDEN SHINER		52	NA	
GOLDEN SHINER		56	NA	
GOLDEN SHINER		56	NA	
GOLDEN SHINER		61	NA	
GOLDEN SHINER		102	8.0	
GOLDEN SHINER		105	7.0	
GOLDEN SHINER		107	7.0	
GOLDEN SHINER		110	8.0	
GOLDEN SHINER		115	12	
GOLDEN SHINER		116	10	
GOLDEN SHINER		116	12	
GOLDEN SHINER		119	12	
GOLDEN SHINER		119	16	
GOLDEN SHINER		120	11	
GOLDEN SHINER		120	9.0	
GOLDEN SHINER		122	12	
GOLDEN SHINER		123	15	
GOLDEN SHINER		123	18	
GOLDEN SHINER		123	12	
GOLDEN SHINER		124	13	
GOLDEN SHINER		124	12	
GOLDEN SHINER		125	6.0	
GOLDEN SHINER		126	13	
GOLDEN SHINER		126	19	
GOLDEN SHINER		126	16	
GOLDEN SHINER		128	16	

TABLE N-17
Fish Length and Weight Summary
Cold Spring Brook Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES	LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
GOLDEN SHINER	128	18	
GOLDEN SHINER	128	18	
GOLDEN SHINER	129	8.0	
GOLDEN SHINER	131	24	
GOLDEN SHINER	132	15	
GOLDEN SHINER	132	11	
GOLDEN SHINER	133	22	
GOLDEN SHINER	133	19	
GOLDEN SHINER	133	18	
GOLDEN SHINER	133	18	
GOLDEN SHINER	133	16	
GOLDEN SHINER	133	22	
GOLDEN SHINER	135	11	
GOLDEN SHINER	135	19	
GOLDEN SHINER	136	18	
GOLDEN SHINER	136	18	
GOLDEN SHINER	136	13	
GOLDEN SHINER	138	27	
GOLDEN SHINER	140	9.0	
GOLDEN SHINER	141	24	
GOLDEN SHINER	143	27	
GOLDEN SHINER	143	29	
GOLDEN SHINER	146	23	
GOLDEN SHINER	147	27	
GOLDEN SHINER	148	22	
GOLDEN SHINER	150	34	
GOLDEN SHINER	157	34	
GOLDEN SHINER	158	36	
Maximum	158	36	
Minimum	52	6	
Average	123.0	16.9	
N=	55	50	
PUMPKINSEED	70	NA	
PUMPKINSEED	72	NA	
PUMPKINSEED	73	NA	
PUMPKINSEED	78	NA	
PUMPKINSEED	106	17	
PUMPKINSEED	108	24	
PUMPKINSEED	116	23	
PUMPKINSEED	118	27	
PUMPKINSEED	118	25	
PUMPKINSEED	119	29	
PUMPKINSEED	121	25	
PUMPKINSEED	131	39	CSBP - 13
PUMPKINSEED	133	48	
PUMPKINSEED	133	45	
PUMPKINSEED	135	38	CSBP - 15
PUMPKINSEED	143	56	
PUMPKINSEED	143	52	CSBP - 14
Maximum	143	56	
Minimum	70	17	
Average	112.8	34.5	
N=	17	13	

TABLE N-17
Fish Length and Weight Summary
Cold Spring Brook Pond

Remedial Investigation Addendum Report
Feasibility Study For Group 1A Sites
Fort Devens, MA

SPECIES	LENGTH (mm)	WEIGHT [a] (g)	ANALYTICAL COLLECTION NUMBER
YELLOW BULLHEAD	38	NA	
YELLOW BULLHEAD	132	41	CSBP - 09
YELLOW BULLHEAD	144	31	CSBP - 07
YELLOW BULLHEAD	133	31	CSBP - 08
YELLOW BULLHEAD	155	58	CSBP - 10
YELLOW BULLHEAD	163	68	CSBP - 11
YELLOW BULLHEAD	167	73	CSBP - 12
Maximum	167	73	
Minimum	38	31	
Average	133.1	50.3	
N=	7.0	6.0	

Notes:
[a] Fish were collected October 20 – 22, 1992. Weight data were not collected for all individuals, as detailed in the text.
[b] These fish were collected but not analyzed for contaminant tissue burden.
NA = Not Available

WETLAND FUNCTIONAL EVALUATION

NEW ENGLAND ENVIRONMENTAL, INC.

WETLAND EVALUATION TECHNIQUE (WET 2.0)

PLOW SHOP POND AND COLD SPRING BROOK POND FORT DEVENS, AYER, MASSACHUSETTS 9 JULY 1993

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I. WET 2.0 EVALUATIONS

Introduction to WET

Wetland Evaluation Technique (WET) assessments were conducted on the existing and post-impact conditions in Cold Spring Pond and Plow Shop Pond, which are located on and adjacent to the Fort Devens Military Installation in Ayer, Massachusetts. WET is a standardized evaluation technique for wetlands which yields a rapid assessment of many of the recognized values and functions of a wetland. Functions and values were evaluated in a Level 2 WET assessment, which is generally considered to be a reasonable balance between time, available information, and level of confidence for most situations. WET uses a standardized manual and answer sheet to provide input data for the WET computer program (See Appendix 1). After data are entered into the WET program, a "Low", "Medium", or "High" value is assigned to each function based upon this input.

A combination of eleven functions (i.e., physical, chemical, and biological characteristics) and values (characteristics beneficial to society) are evaluated by the WET program. Each of these functions and values is defined below. These definitions are found in *Wetland Evaluation Technique Literature Review and Evaluation Rationale* (Adamus et al, 1991).

* **Ground Water Recharge** "is the movement of surface water or precipitation into the ground water flow system".

* **Ground Water Discharge** "is the movement (usually laterally or upward) of ground water into surface water".

* **Floodflow Alteration** "is the process by which peak flows from run-off, surface flow, ground water interflow and discharge, and precipitation enter a wetland and are stored or delayed in their downslope journey".

* **Sediment Stabilization** "consists of both shoreline anchoring and dissipation of erosive forces".

* **Sediment/Toxicant Retention** "is the process by which suspended solids and chemical contaminants such as pesticides and heavy metals adsorbed to them are retained and deposited within a wetland".

* **Nutrient Removal/Transformation** "includes the storage of nutrients within the sediment or plant substrate; the transformation of inorganic nutrients to their

organic forms; and the transformation and subsequent removal of one nutrient (nitrogen) as a gas".

* **Production Export** "refers to the flushing of relatively large amounts of organic material (specifically, carbon from net annual primary and secondary productivity) from the wetland to downstream or adjacent deeper waters".

* **Wildlife Diversity/Abundance** "is the support of a notably great on-site diversity and/or abundance of wetland-dependant birds".

* **Aquatic Diversity/Abundance** "is the support of a notably great on-site diversity and/or abundance of fish or invertebrates that are mainly confined to the water and saturated soils".

* **Uniqueness/Heritage** "includes the use of wetlands for aesthetic enjoyment, nature study, education, scientific research, open space, preservation of rare or endemic species, protection of archaeologically or geologically unique features, maintenance of historic sites, and an infinite number of other mostly intangible uses".

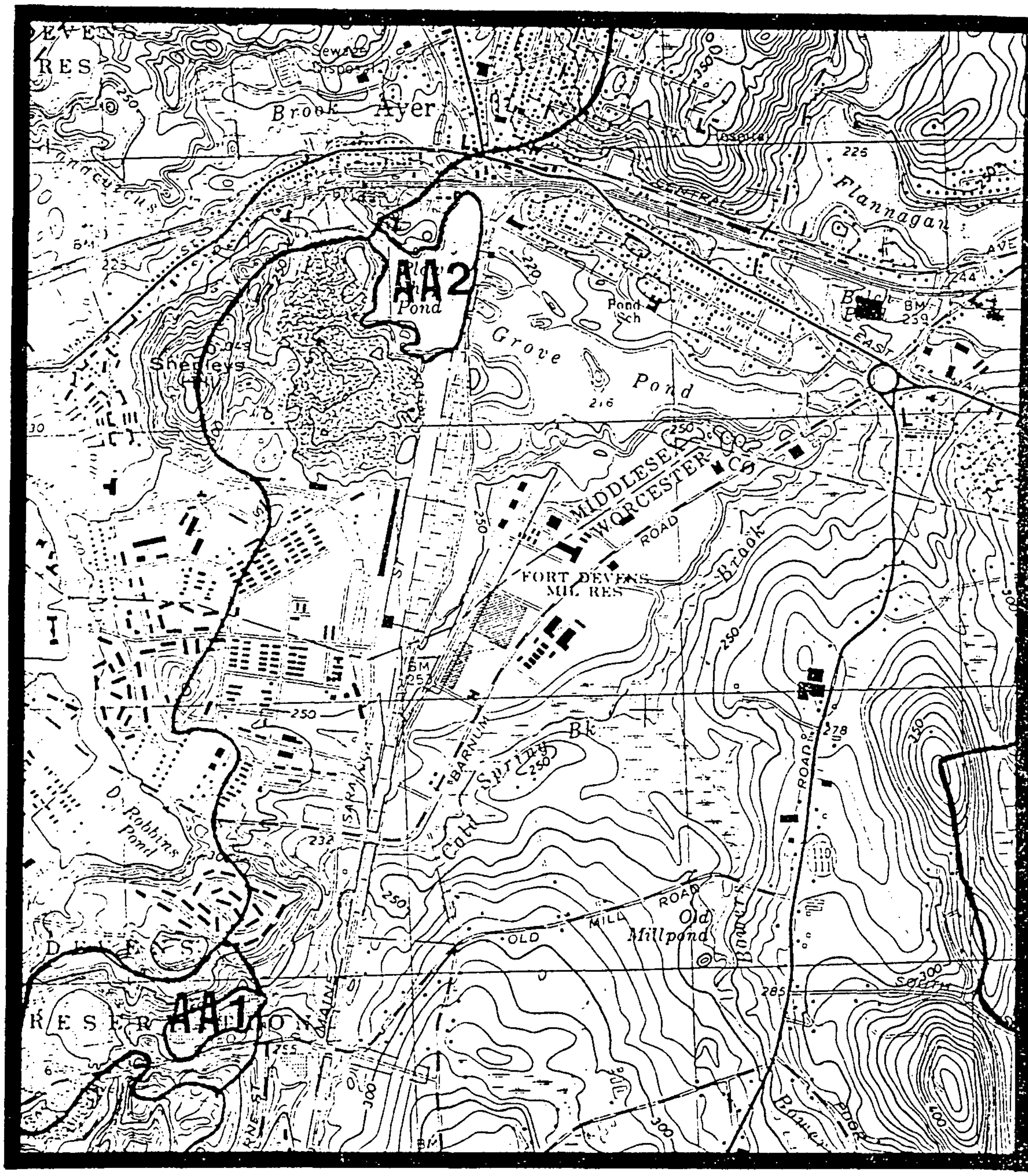
* **Recreation** "includes both consumptive (e.g., sport fishing, food gathering, hunting) and nonconsumptive (e.g., swimming, canoeing, kayaking, birding) forms of recreation that are water dependant and occur in either an incidental or obligatory manner in wetlands".

The above listed functions and values were evaluated by WET in the following contexts: **Social Significance** (the value of the wetland to society); **Effectiveness** (the capability of the wetland to provide the function); and **Opportunity** (the opportunity of the wetland to provide the function).

Using the criteria described in the WET manual, the Assessment Area (AA) for each pond was determined to include not only the ponds, but the surrounding fringe of woody wetland vegetation as well. A WET assessment was conducted based upon the entire AA. A WET evaluation of the probable impacts resulting from removing one foot of sediment from the bottom of each pond was conducted at a point in time three years subsequent to the completion of the work. No detailed plans have yet been formulated for the precise extent of the remediation work. In order to provide a meaningful comparison between the wetlands before and after this work, the boundaries of each Impact Area (IA) were assumed to be

FIGURE 1

NEW ENGLAND ENVIRONMENTAL, INC.



USGS AYER QUADRANGLE
SCALE: 1:25,000

identical to the AA boundary for each pond, although not all of the AA may be altered by the remediation work.

Data for the WET analysis were collected from a number of sources, including the following: site visits by NEE personnel; site reports and documentation provided by ABB, Inc.; previous ecological investigations data by Ecology & Environment, Inc. (June, 1992); the Soil Survey of Middlesex County; FEMA floodplain maps; the USGS Ayer quadrangle; and telephone conversations with the Soil Conservation Service, Natural Heritage and Endangered Species Program, and the National Climactic Data Center. Our evaluation of the WET results is based in part upon the *Wetland Evaluation Technique Literature Review and Evaluation Rationale* (Adamus et al, 1991) and the *Method for Wetland Functional Assessment* (1983).

Cold Spring Brook Pond (AA1)

The first Assessment Area (AA1), Cold Spring Brook Pond, is located to the west of Marne Street (see Figure 1). The boundaries of this AA include the fringe of shrub swamp and wooded swamp which lies to the north of the pond. The western boundary of AA1 is the inlet stream from the upgradient wetland, while the eastern boundary is the culverted outlet beneath Patton Road. The southern limit of this AA is primarily a landfill slope.

Social Significance of AA1

Social Significance is the value of a wetland to society. As shown in Table 1, WET rates the value of Cold Spring Brook Pond to society as "High" for Wildlife Diversity and Abundance as well as Uniqueness and Heritage. There are a number of factors which make the Social Significance of this wetland high for the Wildlife Diversity and Abundance function. Most important, WET bases this function on the ability of the wetland classes within the AA to provide for diversity and abundance of wetland dependant birds, rather than other types of wildlife. Many of the features of this wetland, such as the interspersion of the vegetation and water within the wetland, the moderately irregular edge of the AA, and the proximity of this area to a major river, all make the area important for wetland dependant waterfowl. Moreover, the wetland is located in a region where migratory waterfowl are of major concern. The Social Significance of the Uniqueness and Heritage value is rated as "High" due, in part, to the presence of a long-term monitoring program on the adjacent landfill.

Table 1: Summary of Wet Results for Cold Spring Brook Pond

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	M	*
Floodflow Alteration	L	M	M
Sediment Stabilization	L	H	*
Sediment/Toxicant Retention	L	H	H
Nutrient Removal/Transformation	L	H	H
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	H	*
Wildlife D/A Migration	*	H	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	L	L	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

The Social Significance of the ground water functions are rated by WET as "Moderate" for this wetland, which is due to the downgradient wellfields. The remainder of the evaluated functions are "Low" in Social Significance. The low value of many of these functions is due in part to the small size and watershed of this AA.

Effectiveness of AA1

Effectiveness is the capability of a wetland to perform a given function. Using this parameter, WET rates Cold Spring Brook Pond as "High" for Sediment/Toxicant Retention, Nutrient Removal/Transformation, and Wildlife Breeding and Migration. The Effectiveness of the wetland in performing the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions is enhanced by a number of factors including the low water velocity, constricted outlet, and the shallow water depth within this area. The Effectiveness of the wetland to provide the wildlife functions is based upon a number of factors, including the

interspersion of openwater and vegetation in the wetland, the diversity of the different vegetation types, the shape of the upland/wetland edge, and the sapric substrates within the wetland. Since this function is relative to waterfowl, the fact that Cold Spring Brook Pond has several aquatic bed species which are important food sources for waterfowl increases the Effectiveness of this wetland for Wildlife Diversity/Abundance Migration.

The Effectiveness of this Assessment Area is rated as "Moderate" for Ground Water Discharge, Floodflow Alteration, and Production Export. The wetland is determined to be moderately effective for Ground Water Discharge due to a number of factors, including the landscape position of the AA. Floodflow Alteration Effectiveness is enhanced by the constricted outlet to the wetland. The Effectiveness of Production Export is a function of factors such as the vegetation classes found in the AA and the relatively large portion of its watershed the wetland occupies.

The Effectiveness of this wetland to provide several functions/values is rated as "Low" by WET. For example, the area will have a low value for wintering waterfowl (Wildlife Diversity/Abundance Wintering) due to the fact that it is a shallow wetland and becomes completely frozen during the winter months.

Opportunity of AA1

Most of the functions and values are not evaluated for Opportunity in a Level 2 WET Assessment. Of the three functions/values evaluated, the opportunity for Cold Spring Pond to perform the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions is rated as "High" by WET. Cold Spring Pond has the opportunity to provide these functions due to the proximity of the adjacent landfill. Floodflow Alteration is rated as "Moderate" by WET based upon the high percentage of the watershed this wetland occupies. While the watershed is small, which reduces the opportunity for this function, there are relatively few wetlands upgradient of this area, which increases the opportunity for this function.

Plow Shop Pond (AA2)

Plow Shop Pond (AA2) is located downgradient of AA1, and is situated close to the center of Ayer (see Figure 1). The upper limit of this Assessment Area is the culverted inlet from Grove Pond, while the lower limit is the dammed outlet. The AA includes the narrow fringe of scrub-shrub and forested wetland which surrounds the Pond.

Table 2: Summary of Wet Results for Plow Shop Pond

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	H	U	*
Ground Water Discharge	H	L	*
Floodflow Alteration	L	M	M
Sediment Stabilization	L	M	*
Sediment/Toxicant Retention	M	H	H
Nutrient Removal/Transformation	M	L	H
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	H	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	L	L	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

Social Significance of AA2

Functions which WET determines to be "High" for the Social Significance of Plow Shop Pond are Ground Water Recharge, Ground Water Discharge, Wildlife Diversity and Abundance, and Uniqueness and Heritage. The significance of Plow Shop Pond for the groundwater functions is due to its proximity to downgradient water supply wellfields and the permeable sediments within the area. Like Cold Spring Brook Pond, The Social Significance of Plow Shop Pond for Wildlife

Abundance is rated by WET as "High" based upon the potential attractiveness of the area for migratory waterfowl.

The Social Significance of the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions in this wetland are rated as "Moderate" by WET.

WET rates the Social Significance and Effectiveness of Plow Shop Pond as "Low" for several functions, perhaps the most interesting of which is Aquatic Diversity/Abundance. This low rating is a result of such input data as the water quality problems Plow Shop Pond has experienced as well as the low interspersion of vegetation within the pond. As defined previously, this function is "the support of a notably great on-site diversity and/or abundance of fish or invertebrates that are mainly confined to the water and saturated soil". However, although the WET program predicts that this function is "Low" for Plow Shop Pond, our qualitative evaluation is that the Pond is very valuable for this function based upon the abundance of breeding fish.

Effectiveness of AA2

The Effectiveness, or the capability of AA2 to preform a given function, is rated as "High" for Sediment/Toxicant retention and Wildlife Diversity/Abundance Breeding. As with AA1, the Effectiveness of this wetland for Sediment/Toxicant retention is a function of the physical parameters of the Pond including the constricted outlet, low water velocity, and shallow depth. The breeding function for wildlife is enhanced for Effectiveness by the low gradient, permanent outlet, large watershed, and other factors.

The remainder of the functions and values evaluated by WET are rated as either "Moderate" or "Low" for Effectiveness. As with Social Significance, it is interesting to note that WET determines that the Effectiveness of this wetland for the Aquatic Diversity/Abundance function is "Low". Based upon our on-site visit, we believe that this wetland is very effective at supporting an abundance of warm-water fish species.

Opportunity of AA2

The results for Opportunity for Plow Shop Pond are identical to those for Cold Spring Pond (AA1). As with AA1, most of the functions and values were not

evaluated by WET for Opportunity in this Level 2 WET Assessment. The opportunity for Plow Shop Pond to perform the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions is rated as "High" by WET due to the proximity of the adjacent landfill. The opportunity for AA2 to provide for Floodflow Alteration was rated as "Moderate" by WET.

Impact Area Evaluations

Both Assessment Areas were evaluated based upon the probable impacts resulting from the removal of one foot of sediment from the bottom of each pond. Each Impact Area was evaluated at a point in time three years subsequent to the completion of this work. This time period is arbitrary, and was chosen by NEE to represent a sufficient length of time for aquatic bed vegetation to become re-established. If a shorter time period had been chosen, the WET assessment would have yielded more pronounced impacts. Conversely, since many of the impacts from the proposed work will become less important with time, a WET assessment of the area 5 or 10 years further into the future would have yielded fewer differences between the pre- and post- development functions and values.

WET predicts that the Effectiveness of both IAs will be reduced for the Sediment/Toxicant Retention and Wildlife Diversity/Abundance-Breeding functions, while the Nutrient Removal/Transformation function will be reduced within Cold Spring Brook Pond. The reduction in the Effectiveness of the Sediment/Toxicant Removal function and the Nutrient Removal/Transformation function is due to the alteration of the wetlands. Alterations which destroy vegetation that slows water movement reduces the ability of the wetland to retain sediments. Wetlands which have been excavated are less likely to remove and/or transform nutrients in the water column. In addition, the removal of one foot of sediment will increase the depth of these waterbodies, and deeper wetlands may be less likely to retain sediments and toxicants than shallower wetlands. Finally, the conversion of the substrates within portions of Plow Shop Pond from muck to sand and gravel will reduce the ability of the wetland to trap sediments.

Wildlife Diversity/Abundance-Breeding was determined to be reduced subsequent to the alteration of the area. This is due to the disruption of wetland functions that are important to wildlife following alterations. However, if we had modeled this for longer than 3 years following the alteration, then this would not have had an impact on WET.

Table 3: Summary of Wet Results for Cold Spring Pond, Post-Impact

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	M	*
Floodflow Alteration	L	M	M
Sediment Stabilization	L	H	*
Sediment/Toxicant Retention	L	L	H
Nutrient Removal/Transformation	L	L	H
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	H	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	L	L	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

Table 4: Summary of Wet Results for Plow Shop Pond, Post-Impact

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	H	U	*
Ground Water Discharge	H	L	*
Floodflow Alteration	L	M	M
Sediment Stabilization	L	M	*
Sediment/Toxicant Retention	M	L	H
Nutrient Removal/Transformation	M	L	H
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	L	L	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

WET Summary

A standardized evaluation technique, WET (Wetland Evaluation Technique), was used to conduct assessments on the existing and post-impact conditions in Cold Spring Brook Pond and Plow Shop Pond on the Fort Devens site. The WET analysis determined that the value of both of these wetlands to society is "High" for Wildlife Diversity and Abundance as well as Uniqueness and Heritage. The value of Plow Shop Pond to society is also "High" for Ground Water Recharge and Ground Water Discharge.

WET predicts that the proposed removal of one foot of sediment from the bottom of these ponds will reduce the effectiveness of both wetlands to preform the Sediment/Toxicant Retention and Wildlife Diversity/Abundance-Breeding functions. The Nutrient Removal/Transformation function will be reduced within Cold Spring Brook Pond by the work as predicted by WET.

II. OTHER WETLAND FUNCTIONAL ASSESSMENT METHODS

Hollands and McGee

A Hollands & McGee (H&M) Wetland Functional Assessment (1985) was conducted on Plow Shop Pond and Cold Spring Pond by Ecology and Environment, Inc. as part of their assessment of these wetlands. The Hollands and McGee method was developed by private consulting firms (IEP and Normandeau), and the details of conducting or evaluating this method are generally not available to the public, nor has the complete method been published. The ecological elements in H&M are based largely on the work of Golet & Larson (1974). However, since this method was developed and tested in Massachusetts in 1975, it has the potential for broad applications in the functional assessments of wetlands in this region. The H&M method evaluates 10 wetland functions which incorporate biological, hydrological and socio-cultural interests.

The primary uses of the Hollands and Mcgee method are to compare different wetlands in a region (i.e. a town, county, etc.) so that the relative importance of functional values can be made. This method has been successfully used to evaluate and compare hundreds of wetlands in municipalities in Massachusetts, New Hampshire, and Wisconsin. Although Hollands and McGee (1985) believe that their method compares favorably with more complex methods such as Adamus (1983), which was the precursor to WET 2.0, the two methods have a very different approach. The H&M method relies on expert field personnel which include, at a minimum, a geologist, hydrologist, botanist, and an ecologist to collect site specific detailed data on the wetland(s) being investigated. WET, on the other hand, is designed to be conducted primarily from the office, with minimal field work and non-technical staff. In this respect, the H&M method is similar to the newer Hydrogeomorphic approach which is discussed below.

The H&M wetland evaluation conducted for Cold Spring Brook Pond and Plow Shop Pond provides no regional basis from which to make a decision on the level of the functions found in these wetlands. For instance, the biological model for Plow Shop Pond received a H&M score of 110, while Cold Spring Pond rated 102 for this function. Both were identified as "Moderate" due to a range of scores of this model between 29-158, with a mean of 93. However, practical use of this model indicates that a score of 110 is generally considered "Low" on a regional basis for this part of Massachusetts. Although the H&M system rates these wetlands as "Moderate" in reference to other functional models which require the

output of the biological model, without a comparison of other reference wetlands in the regions, the rating of individual wetland functional values is not appropriate using the H&M method.

Hydrogeomorphic Properties

A recent development in the functional assessment of wetlands is to classify wetlands based on hydrogeomorphic (HGM) properties as is discussed by Brinson et. al (1993, in press). This method is based on a scientific team approach, as in the H&M method, and uses the four following guidelines, or logic train to qualify a function for this method: 1) the function must be clearly defined; 2) it must have recognizable sustaining forces; 3) the function must have hydrologic, geomorphic, or ecologic significance either on the site or off the site; and 4) it must have indicators that can be documented and combined into a functional index that is scaled to reference wetlands.

The HGM method classifies wetlands based on their major properties, such as the geomorphic setting, the sources of water supplying the wetland, and the hydrodynamics of water within the wetland. By first grouping the different wetlands into the HGM classes with similar properties, the functional assessment is defined to address the functions which are linked. This step represents the scientific basis for the presence of the function. The next step is to develop functional profiles for each wetland class. Finally, a scale for expressing functions by using reference wetlands is developed. These reference wetlands are developed for each wetland class in order to serve as the benchmarks for the HGM classes. The reference wetlands are also critical to the setting of goals for compensatory mitigation, and become a standard from which success or failure may be measured. For example, in the H&M wetland functional assessment of both Plow Shop Pond and Cold Spring Brook Pond, no reference was made to the surrounding wetlands, even though there are similar ponds with aquatic beds located in close proximity. A modeled value is of little use if it cannot be compared with either a standard, or a point of reference.

As discussed by the Conservation Foundation (1988), Brinson et al. and Larson and Mazzarese (in press), the general approach which is used to assess the functions of wetlands is to use a generic list of possible wetland functions, and then look for evidence that the wetland being assessed actually performs the functions. As an example, if a given wetland has permanent standing water, is connected to a larger body of water, and has interspersion of both emergent and

submerged vegetation, as in Cold Spring Brook Pond, then it will likely support fish populations, and will thus be determined to have a high probability of aquatic food web support. This general approach has several problems in that a generic series of questions fails to explicitly define the relationship between properties of the wetland and the functions it is supposed to be performing. This "Black Box" approach (Brinson, et al) makes it difficult for the user to understand, learn from, or question the assumed relationships between wetland properties and functions. In fact, these procedures are applied without ever acknowledging the wetland class and its associated attributes.

The HGM approach emphasizes the use of reference wetland populations for the documentation of the relationship between disturbance and function. As such, they are viewed as natural laboratories and as targets for creation and restoration activities. For example, under this approach there is no need to develop complex and detailed design criteria that specify the number of trees to plant, the species composition of the plant community, or the slope and hydroperiod of the wetland surface. Rather, the species composition, cover, density, and other properties of the reference wetlands of a given class can serve as the goals for mitigation. Of importance to any future wetlands mitigation at Fort Devens is that the Discrete use of reference wetland populations in the region of the Base eliminates the need to consider "opportunity" and "effectiveness" as necessary conditions for high rankings of some functions.

Summary

Based on our experience using WET 2.0, Hollands and McGee, and other wetland functional assessment methods, it is our opinion that, if restoration of these wetlands is necessary, then the functional assessments of Plow Shop Pond and Cold Spring Brook Pond should also be compared with other regional wetlands which contain similar characteristics. While WET provides a generic functional assessment of the wetlands, a comparison with other reference wetlands of similar classes would provide a necessary ingredient for future mitigation work. For instance, a fisheries assessment of Plow Shop Pond should be compared with a fisheries assessment of the adjacent Grove Pond, which appears to have many similar characteristics. Any future remediation success of Plow Shop Pond must be measured against not only the existing conditions of the Pond, but against other non-impacted Ponds in the region.

III. QUALITATIVE WETLAND EVALUATIONS

A. COLD SPRING BROOK POND

Introduction

The area surrounding Cold Spring Brook Pond was examined on June 16, 1993. This pond was formed by the construction of Patton Road and the subsequent blockage of the culverted outlet to the wetland. The pond is essentially a dammed part of Cold Spring Brook, with the dam created by a road culvert that passes under Patton Road. Possible dredge spoils and piled peat material are located around parts of the pond perimeter, and this indicates that the pond may have been dredged in the past. The pond is adjacent to the Cold Spring Brook Landfill site (on the west and south) and a magazine storage area (to the west). Cold Spring Brook Pond was generally evaluated as part of a WET evaluation and as part of a qualitative evaluation for plant communities, wetland types, and ecological structure. The purpose of this section is to present a qualitative wetland evaluation of the existing wetland system.

Plant Communities

Four major plant communities were observed within Cold Spring Pond and its fringe wetland: an Aquatic Bed Plant Community; an Emergent Plant Community; a Shrub/Scrub type; and Forested Swamp. Each of these is described separately below.

Aquatic Bed Plant Community

The majority of the Cold Spring Pond wetland system is occupied by an open water aquatic bed plant community. Although the exact bathometric depths are unknown, much of the pond is relatively shallow, and is able to support rooted aquatic plant life that responds to a two meter phototrophic zone. Sweet water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), water marigold (*Megalodonta beckii*), duckweed (*Spirodela* spp.), and coontail (*Ceratophyllum demersum*) were noted in this plant community.

Emergent Plant Community

Much of the shoreline border contains emergent marsh plants, although this band of vegetation is relatively narrow. These plants are generally obligate to facultative wetland plants as rated by the *National List of Plant Species that Occur in Wetlands* (Reed, 1988); these species can easily survive extended periods of saturated soils and flooded conditions. The following plants were observed around the shoreline in the emergent marsh community: tussock sedge (*Carex stricta*), bearded sedge (*Carex comosa*), purple iris (*Iris versicolor*), cattail (*Typha latifolia*), water willow (*Justicia americana*), purple loosestrife (*Lythrum salicaria*), and bugleweed (*Lycopus virginica*).

Shrub/Scrub Plant Community

At the western end of the pond and along parts of the pond perimeter there exists a shrub/scrub wetland plant community. The plant community on the western end is dominated by button bush (*Cephalanthus occidentalis*), smooth alder (*Alnus serrulata*), and silky dogwood (*Cornus amomum*). The understory in this area contains enchanter's nightshade (*Circaea alpina*), sedges (*Carex* spp.), and spotted jewelweed (*Impatiens capensis*). Other perimeter shrub/scrub wetlands are scattered along the perimeter of the pond and contain swamp azalea (*Rhododendron viscosum*), highbush blueberry (*Vaccinium corymbosum*), fetterbush (*Leucothoe racemosa*), winterberry holly (*Ilex verticilatta*), sheep laurel (*Kalmia angustifolia*), maleberry (*Lyonia lingustrina*), and red chokeberry (*Aronia arbutifolia*).

Forested Swamp

There are a few small areas of wetland that are red maple swamps. These areas are located along the fringe of the wetland system and on the peninsula which extends into the pond on its northwestern side. Although red maple (*Acer rubrum*) dominates these areas, gray birch (*Betula populifolia*), silky dogwood (*Cornus amomum*), smooth alder (*Alnus serrulata*), and swamp dewberry (*Rubus hispidus*) are common.

On the southeastern side of this wetland system there is a swamp which is dominated by white pines (*Pinus strobus*) in addition to red maple (*Acer rubrum*). The understory in this area contains american hazelnut, cinnamon fern, and clubmoss.

Wildlife Habitat

Although this report is not intended to provide detailed habitat evaluation, we will briefly discuss the importance of the evaluated area to wildlife. The open water in Cold Spring Pond provides valuable wildlife habitat for many waterfowl species including black ducks, mallards, wood ducks, great blue heron, green heron, and canada goose. While few of these birds nest here, it is very valuable for forage habitat, providing ample hunting and foraging opportunities. Evidence of breeding black duck was observed within this wetland, and the presence of a wood duck nesting box indicates that this species may be breeding here, or has nested here in the past. The wetland is used by a great variety of reptiles and amphibians including: painted turtle; snapping turtle; bullfrog; pickerel frog, green frog, northern water snake, and others. Mammals likely using the area include muskrat, beaver, raccoon, opossum, and northern water shrew. Although there is no recent beaver activity, signs of past beaver activity exist, particularly in the location of the forested landfill area.

The plant community in the wetland and surrounding upland provides good forage, cover, and escape habitat for wildlife. There are many fruit bearing shrubs and trees, as well as good diversity between strata providing ample nesting, foraging, and breeding habitat for a variety of birds and mammals. The area also has a strong ecotone where forest meets open water. As a general assessment, it is our opinion that this pond, as it presently exists, provides a diverse and valuable wildlife habitat.

The open water area provides potential habitat for a variety of benthic macroinvertebrates and fish. Water quality is the driving force that dictates which species can inhabit this particular environment. The most likely fish that may be found in this pond are golden shiners, yellow bullhead, pumpkinseed, and bluegill. Some evidence of fishing in this pond (bobbers, worm containers, fish-hook packages, etc.) was observed, particularly near the outlet end of the pond.

Observed Impacts

Based upon our field observations, the biology of Cold Spring Brook Pond appears to be at relatively normal levels. However, there is a small pond upgradient of Cold Spring Brook Pond which is heavily discolored with a rust colored substance. The aquatic plant life in this pond is reduced in diversity, abundance, and apparent overall health as compared with the downstream Cold Spring Brook

Pond. The channel draining this small pond contains similar coloration as well as a lack of plant and animal diversity and abundance. The small amount of discoloration in Cold Spring Brook pond is primarily near the inlet from this upgradient channel. No other noticeable plumes or areas of apparently impacted plant and animal life were observed.

Wetland Permits

The wetland Resource Areas around Cold Spring Pond have been previously delineated and surveyed by another consultant. Based on our review of the flagged wetland boundaries, it is our opinion that these flagged boundaries do not accurately depict the wetlands which are jurisdictional under the Massachusetts Wetlands Protection Act (M.G.L. chapter 131, section 40) and Regulations (310 CMR 10.00) or under Section 401 and Section 404 of the Clean Water Act. In general, we found that the flagged wetland boundary underestimated the area of wetlands based both upon vegetative criteria, as specified in the Regulations (310 CMR 10.00) to the Act, as well as the three parameter approach as outlined in the *U.S. Army Corps of Engineers Wetland Delineation Manual* (1987).

Only the Ayer Conservation Commission, or the Massachusetts Department of Environmental Protection on appeal, can make the final determination of the extent of the wetland resource areas which are regulated under state law. Similarly, the extent of wetlands which are subject to federal jurisdiction under Section 404 of the Clean Water Act can be determined only by the U.S. Army Corps of Engineers.

Massachusetts Wetland Protection Act

All wetlands on this site are subject to protection under the Massachusetts Wetlands Protection Act. Under the Regulations to the Act, protectable wetlands are broken down into "Resource Areas". The wetland Resource Areas on site include:

* Land Under Waterway or Waterbody (Cold Spring Brook Pond and the streams)
* Bank (the Banks of the Pond and streams)
* Bordering Vegetated Wetland

No portions of this property are within the 100 year floodplain according to the Flood Insurance Rate Map (Ayer, MA. Panel 3 of 4, 1982). The site does not fall

within the estimated range of state-listed rare wetlands wildlife according to the 1993 Natural Heritage and Endangered Species Program Atlas.

Any work which occurs within 100 feet of the wetland Resource Areas on the site is subject to the jurisdiction of the Ayer Conservation Commission, and will require the filing of either a Request for Determination of Applicability or a Notice of Intent. It is possible that any large-scale remediation project would be approved as a Limited Project under section 10.53(4) in the wetlands regulations.

Federal Wetland Jurisdiction under Section 401 of the Clean Water Act

All projects which propose to alter wetlands require Water Quality Certification under Section 401 of the Federal Clean Water Act before work can proceed. Since October 1, 1992 the D.E.P. regions have been administering the 401 Program and now use the state criteria to determine the boundary of wetlands protectable under 401. If the proposed work will alter in excess of 5,000 square feet of wetlands, then the project will be subject to an alternatives analysis and a more lengthy review process by the D.E.P., and may possibly be denied Certification.

Federal Wetland Jurisdiction under Section 404 of the Clean Water Act

All wetlands on the property are subject to protection under Section 404 of the Clean Water Act. The boundary of wetlands which are protectable under Section 404 is different than that delineated under the Wetlands Protection Act and Section 401 of the Clean Water Act. On this site, it appears that the flagged wetland boundary <u>does not</u> reflect the extent of the wetlands which would be delineated based upon the methodology described in the *U.S. Army Corps of Engineers Wetland Delineation Manual* (1987). This manual describes a multiple parameter methodology which uses the presence of hydric soils, hydrophytic vegetation, and wetland hydrology to establish the boundary of the wetlands. This manual has superseded the more recent *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989) for federal wetland boundary delineations.

TABLE 5: PLANT SPECIES FOUND IN WETLANDS, COLD SPRING BROOK POND, FORT DEVENS, AYER, MASSACHUSETTS

COMMON NAME	SCIENTIFIC NAME	INDICATOR STATUS*
Trees		
Red Maple	*Acer rubrum*	FAC
Gray Birch	*Betula populifolia*	FAC
Green Ash	*Fraxinus pennsylvanica*	FACW
Red Pine	*Pinus resinosa*	FACU
White Pine	*Pinus strobus*	FACU
Quaking Aspen	*Populus tremula*	FACU
Black Cherry	*Prunus serotina*	FACU
White Oak	*Quercus alba*	FACU-
Red Oak	*Quercus rubra*	FACU-
American Elm	*Ulmus americana*	FACW-
Shrubs		
Speckled Alder	*Alnus rugosa*	FACW+
Smooth Alder	*Alnus serrulata*	OBL
Red Chokeberry	*Aronia arbutifolia*	FACW
Common Buttonbush	*Cephalanthus occidentalis*	OBL
Silky Dogwood	*Cornus amomum*	FACW
American Hazelnut	*Corylus americana*	FACU-
Witch Hazel	*Hamamelis virginiana*	FAC-
Winterberry Holly	*Ilex verticillata*	FACW+
Sheep Laurel	*Kalmia angustifolia*	FAC
Fetterbush	*Leucothoe racemosa*	FACW
Maleberry	*Lyonia ligustrina*	FACW
Mountain Holly	*Nemopanthus mucronatus*	OBL
Swamp Azalea	*Rhododendron viscosum*	OBL
Willows	*Salix* spp.	FACW
Meadowsweet	*Spirea latifolia*	FAC+
Steeplebush	*Spirea tomentosa*	FACW
Highbush Blueberry	*Vaccinium corymbosum*	FACW-

Lowbush Blueberry	*Vaccinium angustifolium*	FACU-
Wild Raisin	*Viburnum cassinoides*	FACW
Northern Arrowwood	*Viburnum recognitum*	FACW-

Ilianas

Poison Ivy	*Toxicodendron radicans*	FAC
Grape	*Vitis* spp.	FACW-FACU

Ferns

Spinulose Woodfern	*Dryopteris spinulosa*	FAC+
Field Horsetail	*Equisetum arvense*	FAC
Princess Pine Clubmoss	*Lycopodium obscurum*	FACU
Sensitive Fern	*Onoclea sensibilis*	FACW
Cinnamon Fern	*Osmunda cinnamomea*	FACW
Interrupted Fern	*Osmunda claytoniana*	FAC
Royal Fern	*Osmunda regalis*	OBL
Bracken Fern	*Pteridium aquilinum*	FACU
New York Fern	*Thelypteris noveboracensis*	FAC
Marsh Fern	*Thelypteris thelypteroides*	FACW+

Forbs

Jack-In-The-Pulpit	*Arisaema triphyllum*	FACW-
Swamp Milkweed	*Asclepias incarnata*	OBL
Aster	*Aster* spp.	
Spotted Wintergreen	*Chimaphila maculata*	UPL
Goldthread	*Coptis trifolia*	FACW
Spotted Joe-Pye-Weed	*Eupatoriadelphus maculatus*	FACW
Boneset	*Eupatorium perfoliatum*	FACW+
Bedstraw	*Galium* spp.	
Hawkweeds	*Hieracium* spp.	UPL
Bluets	*Houstonia* spp.	FAC-FACU
Spotted Jewelweed	*Impatiens capensis*	FACW
Yellow Iris	*Iris pseudoacorus*	OBL
Blueflag Iris	*Iris versicolor*	OBL

Duckweed	*Lemna* spp.	OBL
Bugleweed	*Lycopus virginicus*	OBL
Purple Loosestrife	*Lythrum salicaria*	FACW+
Canada Maylower	*Maianthemum canadense*	FAC-
Water-Millfoil	*Myriophyllum* spp.	OBL
Water Lily	*Nuphar* spp.	OBL
Pale Smartweed	*Polygonum lapathifolium*	FACW+
Pickerelweed	*Pontederia cordata*	OBL
Pondweed	*Potamogeton* spp.	OBL
Swamp Buttercup	*Ranunculus septentrionalis*	OBL
Blackberry	*Rubus* spp.	
Dewberry	*Rubus hispidus*	FACW
Curled Dock	*Rumex crispus*	FACU
Arrowhead	*Saggitaria latifolia*	OBL
Tall Goldenrod	*Solidago altissima*	FACU-
Rough Goldenrod	*Solidago rugosa*	FAC
Skunk Cabbage	*Symplocarpus foetidus*	OBL
Common Cattail	*Typha latifolia*	OBL
Violet	*Viola* spp.	FACW-OBL

<u>Grasses and Grasslike Species</u>

Fringed Sedge	*Carex crinita*	OBL
Broom Sedge	*Carex scoparia*	FACW
Tussock Sedge	*Carex stricta*	OBL
Blunt Broom Sedge	*Carex tribuloides*	FACW+
Other Sedges	*Carex* spp.	FACW-OBL
Spike-Rush	*Eleocharis* spp.	FACW+-OBL
Other Grasses	*Graminaceae*	
Canada Rush	*Juncus canadensis*	OBL
Soft Rush	*Juncus effusus*	FACW+
Rice Cut-Grass	*Leersia oryzoides*	OBL
Haircap Moss	*Polytrichum commune*	FACU**
Sphagnum Moss	*Sphagnum* spp.	OBL**

Category	Symbol	Definition
OBLIGATE HYDROPHYTE	OBL	Nearly always occurs in wetlands (>99%)
FACULTATIVE WETLAND	FACW	Usually occurs in wetlands (67% to 99%)
FACULTATIVE	FAC	Commonly occurs in both wetlands and uplands (34% to 66% in wetlands)
FACULTATIVE UPLAND	FACU	Usually occurs in uplands, but may occasionally occur in wetlands (1% to 33%)
UPLAND	UPL	Nearly always occurs in uplands (<1% in wetlands)

A positive (+) sign behind the Facultative Indicator categories indicates a frequency toward the higher end of the category (more frequently found in wetlands), while a negative (-) sign indicates a frequency toward the lower end of the category (less frequently found in wetlands).

D = Dominant (> 50% cover)
C = Common (11%-49% cover)
O = Occasional (1%-10% cover)

* 1988 Wetland Plant List, Northeast Region. National Wetlands Inventory, U.S. Fish and Wildlife Service.

** Indicator status for mosses assigned by experience of NEE personnel; mosses are not rated by Wetland Plant List (1988).

PLOW SHOP POND

Introduction

The Plow Shop Pond wetlands were examined on June 16, 1993 by New England Environmental, Inc. (NEE) biologists. This pond and the adjacent wetlands are located in the northeast corner of the Main Post at Fort Devens, adjacent to the Shepley's Hill Landfill. The pond receives water from Grove Pond and a relatively large upgradient watershed. The Pond drains into Nonacoicus Brook, which eventually discharges into the Nashua River. Plow Shop Pond is an impounded area, with the primary outlet feeding Nonacoicus Brook. Plow Shop Pond is approximately 30 acres in size. This area and the associated wetlands were evaluated by New England Environmental, Inc. as part of a WET evaluation of wetland functional values, and as part of a qualitative evaluation for plant communities, wetland types, and ecological regime. The purpose of this section is to present a qualitative evaluation of the existing wetland system.

Plant Communities

Four major plant communities were observed within Plow Shop Pond and its fringe wetland, although the vast majority of the system is Aquatic Bed. The Emergent Plant Community, Shrub/Scrub type, and Forested Swamp are found in a narrow band which surrounds the Pond. Each of these plant communities is described separately below.

Aquatic Bed Plant Community

The majority of this wetland system is an open water aquatic bed plant community. Much of the area is less than 6.6 feet deep, which helps to describe it as shallow and capable of supporting a dense rooted vascular plant community. Sweet water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), duckweed (*Spirodela spp.*), coontail (*Ceratophyllum demersum*), milfoil (*Myriophyllum spp.*), northern arrowhead (*Sagittaria cuneata*), and pickerelweed (*Pontedaria cordata*) were all noted in this community and comprise 80-90% of the plant species present.

Emergent Plant Community

Emergent marsh plants were noted along the majority of the shoreline border. These plants are generally obligate wetland species, with some facultative wetland plant species also present. The following species were noted along the shoreline as part of the emergent plant community: tussock sedge (*Carex stricta*), bugleweed (*Lycopus virginica*), bearded sedge (*Carex comosa*), purple iris (*Iris versicolor*), broadleaf cattail (*Typha latifolia*), yellow iris (*Iris pseudacorus*), eastern burreed (*Sparganium americanum*), soft-stemmed bullrush (*Scirpus validus*), water smartweed (*Polygonum punctatum*), purple loosestrife (*Lythrum salicaria*), and lurid sedge (*Carex lurida*).

Shrub/Scrub Wetland Plant Community

The majority of the wetland fringe around Plow Shop Pond contains a shrub/scrub wetland plant community. This plant community is found in association with many small red maple (*Acer rubrum*) saplings. The shrub/scrub plant community contains the following species: smooth alder (*Alnus serrulata*), speckled alder (*Alnus rugosa*), highbush blueberry (*Vaccinium corymbosum*), maleberry (*Lyonia lingustrina*), swamp azalea (*Rhododendron viscosum*), northern arrow-wood (*Viburnum recognitum*), wild raisin (*Viburnum cassanoides*), mountain holly (*Nemopanthus mucronta*), sheep laurel (*Kalmia angustifolia*), silky dogwood (*Cornus amomum*), ironwood (*Carpinius caroliniana*), witch-hazel (*Hammamelis virginiana*), and winterberry holly (*Ilex verticilata*). The understory of this narrow fringe community contained many species including spotted jewelweed (*Impatiens capensis*), marsh fern (*Thelypteris thelypteroides*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnomomea*), skunk cabbage (*Symplocarpus foetidus*), peat moss (*Sphagnum spp.*), haircap moss (*Polytrichum commune*), staghorn clubmoss (*Lycopodium clavatum*), virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicondendron radicans*).

Forested Swamp Community

In an area adjacent near the pond outlet (Nonacoicus Brook), there is a red maple swamp forested wetland. The overstory is dominated by red maple and gray birch (*Betula populifolia*), and silver maple (*Acer saccharinum*). In the shrub layer wild raisin, nannyberry (*Viburnum lentago*), and highbush blueberry are found. The understory is dominated by cinnamon fern, marsh fern, jewelweed, and joe-pye weed (*Eupatorium maculatum*).

Wildlife Habitat

Although it is beyond the scope of this report to provide a detailed wildlife habitat evaluation of Plow Shop Pond, we are providing a general discussion of the more important wildlife habitats which were evaluated in this study. The approximately 30 acres of open water found in Plow Shop Pond presently provides excellent brood-rearing and migratory feeding habitat for many waterfowl species including black duck, mallard, wood duck, great blue heron, green-backed heron, and canada goose. Although there are suitable nesting areas for waterfowl adjacent to the Pond, we did not observe any waterfowl broods during our one day site visit. The pond area has large areas of aquatic vegetation for forage and brood-rearing by many species of dabbling ducks and geese, and is likely to be heavily used by migrating waterfowl. There is little habitat interspersion or cover within the main body of the pond, which reduces somewhat the habitat value for several waterfowl species (i.e. wood duck), although the several wooded coves and outlet wetland provide additional habitat interspersion.

The Plow Shop Pond wetland system is used by a variety of reptiles and amphibians which were observed within the area including: painted turtle; snapping turtle; northern water snake; bullfrog; and green frog. Although several species of salamanders are likely to occur within this wetland complex, none were observed during our site visit. Mammals observed or which are likely using the area are muskrat, beaver, raccoon, opossum, and northern water shrew. There is some recent sign of beaver activity along the southern edge of the pond, and muskrat were observed in several of the small coves. Raccoon tracks were observed within the wetlands.

The plant community in the wetland and surrounding upland provides good shade, forage, cover, and escape habitat. There are a diverse variety of fruit and mast bearing shrubs and trees (ie. highbush blueberry, red oak), and a good interspersion of plant strata providing nesting, foraging, and breeding habitat for many different bird and mammal species. A very large and important ecotone exists where open water meets forest and shrub areas. As a general assessment, it is our opinion that Plow Shop Pond and the adjacent wetlands presently provides good wildlife habitat for a diverse group of fish and animal species.

The open water area of Plow Shop Pond provides potential habitat for a variety of benthic macroinvertebrates and warm water fish. Water quality is the primary ingredient in determining which species inhabit this environment. The most

likely fish that may be found in this pond, and those which we observed are: golden shiners; yellow bullhead; pumpkinseed; bluegill; large mouth bass; and chain pickerel. Ample evidence exists of fishing in the area (rod-holders, bait cans, trash, bobbers, etc.). There are presently posted warning signs which indicate that Plow Shop Pond is a catch and release area only.

Our site inspection was impressed by the large numbers of nesting bluegills found around almost the entire perimeter of the pond in shallow gravelly substrates. Equally impressive were the large number and the great size of large mouth bass which were observed near the inlet, the outlet, and throughout the aquatic bed.

Observed Impacts

Shepley's Hill Landfill is situated to an area south and adjacent to Plow Shop Pond. Two coves extend from the main body of the Pond towards the landfill, and these coves contain a red precipitate. This precipitate was not observed in any other areas of the Pond. In the northern cove, a steady plume of groundwater was observed to be discharging into the area.

There was a marked contrast of the plant communities within these two coves as compared to the greater body of water of Plow Shop Pond, with a general lack of plant diversity, especially in the northern cove. In addition, several dead trees (white pine and red maples) were observed adjacent to the northern cove. No other obvious tree diebacks were observed around the entire perimeter of Plowshop Pond. The aquatic plant life in the northern cove was sparse and unhealthy in appearance in comparison with the rest of the pond, and much of the aquatic vegetation had absorbed the rust-colored precipitate. Almost all of the pond bottom in the northern cove was rust-colored. Several nesting bluegills were observed within the northern cove.

At the southern cove, similar observations were made, although the observed impacts were less pronounced. At this cove, there was no observed plume of water entering the area, and there was less discoloration. The area did appear to contain a lack of diversity in aquatic plant species. No fish were observed in the southern cove.

Wetland Permits

The wetland Resource Areas around Plow Shop Pond have been previously

delineated and surveyed by another consultant. New England Environmental, Inc. generally agrees with the boundaries as established by the flags in the field, however; only the Ayer Conservation Commission, or the Massachusetts Department of Environmental Protection on appeal, can make the final determination of the extent of the wetlands which are regulated under state law. Similarly, the extent of wetlands which are subject to federal jurisdiction under Section 404 of the Clean Water Act can be determined only by the U.S. Army Corps of Engineers.

Massachusetts Wetlands Protection Act

All wetlands on this site are subject to protection under the Massachusetts Wetlands protection Act. Under the Regulations of the Act, protectable wetlands are broken down into "Resource Areas". According to the Flood Insurance Rate Map (Ayer, MA., Panel 3 of 4), there is a significant area surrounding Plow Shop Pond which is subject to flooding in the 100 year storm event. This area of flooding extends to adjacent areas down stream. The wetland Resource Areas on the site include:

* Land Under a Waterway and Waterbody (Plow Shop Pond and inlet/outlet)
* Bank (the Banks of the Pond and streams)
* Bordering Vegetated Wetland
* Bordering Land Subject to Flooding (100 year floodplain)

The site does not fall within the estimated range of state-listed rare wetlands wildlife according to the 1993 Natural Heritage and Endangered Species Program Atlas.

A wetland filing with the Ayer Conservation Commission will be required for any proposed remediation work. It is likely that any large-scale remediation project can be approved as a Limited Project under section 10.53(4) or perhaps other appropriate sections in the wetlands regulations.

Federal Wetland Jurisdiction under Section 401 of the Clean Water Act

All projects which propose to alter wetlands require Water Quality Certification under Section 401 of the Federal Clean Water Act before work can proceed. Since October 1, 1992 the D.E.P. regions have been administering the 401 Program and now use the state criteria to determine the boundary of wetlands protectable

under 401. If the proposed work will alter in excess of 5,000 square feet of wetlands, then the project will be subject to an alternatives analysis and a more lengthy review process by the D.E.P., and may possibly be denied Certification.

Federal Wetland Jurisdiction under Section 404 of the Clean Water Act

All wetlands on the property are subject to protection under Section 404 of the Clean Water Act. The boundary of wetlands which are protectable under Section 404 is different than that delineated under the Wetlands Protection Act and Section 401 of the Clean Water Act. On this site, it appears that the flagged wetland boundary generally coincides with the line which would have been delineated based solely upon the methodology described in the *U.S. Army Corps of Engineers Wetland Delineation Manual* (1987). This manual describes a multiple parameter methodology which uses the presence of hydric soils, hydrophytic vegetation, and wetland hydrology to establish the boundary of the wetlands. This manual has superseded the more recent *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989) for federal wetland boundary delineations.

TABLE 5: PLANT SPECIES FOUND IN PLOW SHOP POND WETLANDS.

COMMON NAME	SCIENTIFIC NAME	INDICATOR STATUS*
Trees		
Red Maple	*Acer rubrum*	FAC
Silver Maple	*Acer saccharinum*	FACW
Gray Birch	*Betula populifolia*	FAC
Ironwood	*Carpinus caroliniana*	FAC
Red Pine	*Pinus resinosa*	FACU
White Oak	*Quercus alba*	FACU-
Red Oak	*Quercus rubra*	FACU-
American Elm	*Ulmus americana*	FACW-
Shrubs		
Speckled Alder	*Alnus rugosa*	FACW+
Smooth Alder	*Alnus serrulata*	OBL
Common Buttonbush	*Cephalanthus occidentalis*	OBL
Silky Dogwood	*Cornus amomum*	FACW
American Hazelnut	*Corylus americana*	FACU-
Black Huckleberry	*Gaylussacia baccata*	FACU
Witch Hazel	*Hamamelis virginiana*	FAC-
Sheep Laurel	*Kalmia angustifolia*	FAC
Maleberry	*Lyonia ligustrina*	FACW
Sweetgale	*Myrica gale*	OBL
Mountain Holly	*Nemopanthus mucronatus*	OBL
Pink Azalea	*Rhododendron nudiflorum*	FAC
Swamp Azalea	*Rhododendron viscosum*	OBL
Staghorn Sumac	*Rhus typhina*	UPL
Willows	*Salix* spp.	FACW
American Elderberry	*Sambucus canadensis*	FACW-
Meadowsweet	*Spirea latifolia*	FAC+
Steeplebush	*Spirea tomentosa*	FACW
Highbush Blueberry	*Vaccinium corymbosum*	FACW-
Wild Raisin	*Viburnum cassinoides*	FACW

Nannyberry	*Viburnum lentago*	FAC
Northern Arrowwood	*Viburnum recognitum*	FACW-

Ilianas

Virginia Creeper	*Parthenocissus quinquefolia*	FACU
Poison Ivy	*Toxicodendron radicans*	FAC

Ferns

Lady Fern	*Athyrium Filix-femina*	FAC
Spinulose Woodfern	*Dryopteris spinulosa*	FAC+
Staghorn Clubmoss	*Lycopodium clavatum*	FAC
Sensitive Fern	*Onoclea sensibilis*	FACW
Cinnamon Fern	*Osmunda cinnamomea*	FACW
Royal Fern	*Osmunda regalis*	OBL
Bracken Fern	*Pteridium aquilinum*	FACU
New York Fern	*Thelypteris noveboracensis*	FAC

Forbs

Ground Nut	*Apios americana*	FACW
Jack-In-The-Pulpit	*Arisaema triphyllum*	FACW-
Aster	*Aster* spp.	
Bog Hemp	*Boehmeria cylindrica*	FACW+
Water Shield	*Brasenia schreberi*	OBL
Coontail	*Ceratophyllum demersum*	OBL
Goldthread	*Coptis trifolia*	FACW
Spotted Joe-Pye-Weed	*Eupatoriadelphus maculatus*	FACW
Strawberry	*Fragaria virginiana*	FACU
Bedstraw	*Galium* spp.	
Hawkweeds	*Hieracium* spp.	UPL
Bluets	*Houstonia* spp.	FAC-FACU
Spotted Jewelweed	*Impatiens capensis*	FACW
Yellow Iris	*Iris pseudoacorus*	OBL
Blueflag Iris	*Iris versicolor*	OBL
Bugleweed	*Lycopus virginicus*	OBL
Yellow Loosestrife	*Lysimachia terrestris*	OBL
Purple Loosestrife	*Lythrum salicaria*	FACW+

Canada Maylower	*Maianthemum canadense*	FAC-
Water Marigold	*Megalodonta beckii*	OBL
Forget-me-not	*Myosotis scorpioides*	OBL
Water-Millfoil	*Myriophyllum* spp.	OBL
Sweet Water Lily	*Nymphaea odorata*	OBL
Pale Smartweed	*Polygonum lapathifolium*	FACW+
Pickerelweed	*Pontederia cordata*	OBL
Pondweed	*Potamogeton* spp.	OBL
Common Cinquefoil	*Potentilla simplex*	FACU-
Buttercup	*Ranunculus spp.*	FAC-OBL
Blackberry	*Rubus* spp.	
Dewberry	*Rubus hispidus*	FACW
Raspberry	*Rubus* spp.	
Arrowhead	*Saggitaria latifolia*	OBL
Rough Goldenrod	*Solidago rugosa*	FAC
Goldenrod	*Solidago* spp.	
Skunk Cabbage	*Symplocarpus foetidus*	OBL
Common Cattail	*Typha latifolia*	OBL

<u>Mosses and Grass-like Plants</u>

Blue Joint Grass	*Calamagrostis canadensis*	FACW+
Fringed Sedge	*Carex crinita*	OBL
Lurid Sedge	*Carex lurida*	OBL
Broom Sedge	*Carex scoparia*	FACW
Stalk-Grain Sedge	*Carex stipata*	OBL
Tussock Sedge	*Carex stricta*	OBL
Blunt Broom Sedge	*Carex tribuloides*	FACW+
Other Sedges	*Carex* spp.	FACW-OBL
Other Grasses	*Graminaceae*	
Timothy	*Phleum pratense*	FACU
Flat Bluegrass	*Poa compressa*	
Haircap Moss	*Polytrichum commune*	FACU**
Softstem Bulrush	*Scirpus validus*	OBL
Bur Reed	*Sparganium* spp.	OBL
Sphagnum Moss	*Sphagnum* spp.	OBL**

Category	Symbol	Definition
OBLIGATE HYDROPHYTE	OBL	Nearly always occurs in wetlands (>99%)
FACULTATIVE WETLAND	FACW	Usually occurs in wetlands (67% to 99%)
FACULTATIVE	FAC	Commonly occurs in both wetlands and uplands (34% to 66% in wetlands)
FACULTATIVE UPLAND	FACU	Usually occurs in uplands, but may occasionallyoccur in wetlands (1% to 33%)
UPLAND	UPL	Nearly always occurs in uplands (<1% in wetlands)

A positive (+) sign behind the Facultative Indicator categories indicates a frequency toward the higher end of the category (more frequently found in wetlands), while a negative (-) sign indicates a frequency toward the lower end of the category (less frequently found in wetlands).

D = Dominant (> 50% cover)
C = Common (11%-49% cover)
O = Occasional (1%-10% cover)

* 1988 Wetland Plant List, Northeast Region. National Wetlands Inventory, U.S. Fish and Wildlife Service.

** Indicator status for mosses assigned by experience of NEE personnel; mosses are not rated by Wetland Plant List (1988).

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APPENDIX E

WET DATA FORMS

WET - COLDSPRIN

FORM A: SITE DOCUMENTATION (Page 1 of 2)

Part 1 - Background Information AA 1

Evaluation Site: COLD SPRING POND Date: 6-18-93

Site Location (Section, Range, and Township): AYER

Has the evaluator taken a training course in WET Version 2.0? Yes

Agencies/Experts Contacted: SCS, NOAA, MA F+W, NAT. HERITAGE

Circle the assessment levels to be completed? SS-1 SS-2 E/O-1&2 E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
Non-tidal, Wet Cond. – Hydro – March, Veg – May; Dry Cond. Avg. – Hydrology – Avg. Veg – August. Avg. Cond – Hyd – June, Veg – Sept.

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
NO

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? NO

Part 2 - Identification and Delineation of Evaluation Areas

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information: See Figure 1

-- Boundaries of the AA, IA, and IZ, and the location of service areas.
-- Watershed boundaries of AA, and service areas.
-- Extent of surface water in the AA during the wet and dry seasons.
-- Open water (channels and pools) within and adjacent to the AA.
-- Normal direction of channel or tidal flow
-- Normal direction of wind-driven waves or current.
-- Impact area(s).
-- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = ±3 acres
Impact Area = N/A acres (only if applicable)
Watershed of AA = ±50 acres/ 0.08 miles^2 (acres x 0.0016 = miles)
Wetlands in AA = ±3 acres
Wetlands in the watershed of closest service area = 7500 acres
Wetlands and deepwater in the watershed of closest service area = 7500 acres

How were locality and region defined for this evaluation?

locality - Town (Ayer)
Region - State (Massachusetts)

Sketch of Evaluation Areas (or attach map):

See Figure 1

FORM B: EVALUATION ANSWER SHEET

Evaluation Site: Cold Spring Pond AA-1

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

3.1.1 "Red Flags"

				Comments/Assumptions
s1.	Y	N	U	NOT LISTED BY MA, NAT. HERITAGE
s2.	Y	N	U	
s3.	Y	N	U	
s4.	Y	N	U	
s5.	Y	N	U	
s6.	Y	N	U	

3.1.2 On-site Social Significance

					Comments/Assumptions
s7.	Y	N	U	I	
s8.	Y	N	U	I	- SUPERFUND SITE

3.1.3 Off-site Social Significance

					Comments
s9.	Y	N	U	I	
s10.	Y	N	U		
s11.	Y	N	U		
s12.	Y	N	U		
s13.	Y	N	U		
s14.	Y	N	U		
s15.	Y	N	U	I	· ESTIMATED HABITAT MAP
s16.	Y	N	U	I	· GROVE POND WELL FIELD
s17.	Y	N	U	I	
s18.	Y	N	U	I	
s19.	Y	N	U		
s20.	Y	N	U		NO IMPORTANT FISH

					Comments
s21.	Y	N	U		BLACK DUCK/WOOD DUCK
s22.	Y	N	U	I	
s23.	Y	N	U		
s24.	Y	N	U		
s25.	Y	N	U		[illegible]
s26.	Y	N	U		
s27.	Y	N	U		NO LOC[illegible]
s28.	Y	N	U		
s29.	Y	N	U		- [illegible]
s30.	Y	N	U		
s31.	Y	N	U		- [illegible]

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
- Standard Density Circle
- Locality
- Hydrologic Unit

Question #

			Comments/Assumptions
1	Y	N	- [illegible]
2	Y	N	[illegible]
3	Y	N	- [illegible] FLOO[illegible]
4	Y	N	- FLO[illegible]

Evaluation Site: COLD SPRINGS A #1

EFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 1 (OFFICE)

Q.#	WETLAND CONDITION $\overline{X}$	W	D	COMMENTS/ASSUMPTIONS
1.1	Y N			
1.2	Y N			– [illegible] SCS
1.3	Y N			
2.1.1	Y N			
2.1.2	Y N			
2.1.3	Y N			
2.2.1	Y N I			
2.2.2	Y N I			[illegible] FIELD OBS.
3.1	Y N			
3.2	Y N			NWI MAPS
3.3	Y N			NWI MAPS
4.1	Y N			– NASHUA/MERRIMACK RIVER
4.2A	Y N			– USGS
4.2B	Y N			
4.2C	Y N			
4.2D	Y N			
5.1.1		Y N		
5.1.2		Y N		
5.2		Y N		
6.1	Y N			USGS
6.2	Y N			FIELD INVESTIGATION
7	Y N I			
8.1	Y N			– FIELD OBS
8.2	Y N			
8.3	Y N			– USGS & FIELD
8.4	Y N			
9.1		Y N		– CONSTRICTED OUTLET
9.2		Y N I		
9.3		Y N I		– GNDWATER DIS.
10A	Y N			– AQUATIC BED
10B	Y N			
10C	Y N			
10D	Y N			
10E	Y N			
10F	Y N			

FORM B (Cont.)

Evaluation Site: COLD SPRING - AA 1

WETLAND CONDITION

Q.#	$\overline{X}$	W	D
11	Y N	Y N	Y N
12A	Y N	Y N	Y N
12Aa	Y N	Y N	Y N
12Ab	Y N	Y N	Y N
12Ac	Y N	Y N	Y N
12Ad	Y N	Y N	Y N
12Ae	Y N	Y N	Y N
12B	Y N	Y N	Y N
12Ba	Y N	Y N	Y N
12Bb	Y N	Y N	Y N
12Bc	Y N	Y N	Y N
12Bd	Y N	Y N	Y N
12Be	Y N	Y N	Y N
12C	Y N	Y N	Y N
12Ca	Y N	Y N	Y N
12Cb	Y N	Y N	Y N
12Cc	Y N	Y N	Y N
12Cd	Y N	Y N	Y N
12D	Y N	Y N	Y N
12Da	Y N	Y N	Y N
12Db	Y N	Y N	Y N
12E	Y N	Y N	Y N
13A	Y N	Y N	Y N
13Aa	Y N	Y N	Y N
13Ab	Y N	Y N	Y N
13Ac	Y N	Y N	Y N
13Ad	Y N	Y N	Y N
13Ae	Y N	Y N	Y N
13B	Y N	Y N	Y N
13Ba	Y N	Y N	Y N
13Bb	Y N	Y N	Y N
13Bc	Y N	Y N	Y N
13Bd	Y N	Y N	Y N
13Be	Y N	Y N	Y N
13C	Y N	Y N	Y N
13Ca	Y N	Y N	Y N
13Cb	Y N	Y N	Y N
13Cc	Y N	Y N	Y N
13Cd	Y N	Y N	Y N
13D	Y N	Y N	Y N
13Da	Y N	Y N	Y N
13Db	Y N	Y N	Y N
13E	Y N	Y N	Y N

COMMENTS/ASSUMPTIONS

DOMINANT A - AQUATIC BED, ROOTED VASCULAR

EDGE B - SHRUB/SCRUB BROAD LEAF DECIDUOUS

C - AQUATIC BED, ROOTED VASCULAR

>10% - AQUATIC BED

>10% - FORESTED BE

>10% - SHRUB/SCRUB

FORM B (Cont.)

Evaluation Site: COLD SPRING POND - AA 1

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D	Comments
14.1	Y N	Y N	Y N	FIELD OBSERV.
14.2	Y N	Y N	Y N	
15.1A	Y N I			
15.1B	Y N I	FIELD OBSERV.		
15.1C	Y N I			
15.2	Y N I	NO CHANNEL FLOW		
16A	Y N	Y N	Y N	FIELD OBSERV.
16B	Y N	Y N	Y N	
16C	Y N	Y N	Y N	
17	Y N	< 70% ANY CLASS		
18	Y N I			
19.1A	Y N I - TREES, [illegible]			
19.1B	Y N I			
19.2	Y N I			
19.3	Y N I			
20.1	Y N I			
20.2	Y N I			
21A	Y N - MOSTLY FOREST[illegible] ALTHOUGH SIG. LANDFILL AREA			
21B	Y N			
21C	Y N			
21D	Y N			
21E	Y N			
22.1.1	Y N			
22.1.2	Y N I			
22.2	Y N			
22.3	Y N I			
23	Y N CONSTRICTING CULVERTS			
24.1	Y N I - SCS SOILS MAP			
24.2	Y N I			
24.3	Y N I			
24.4	Y N I			
24.5	Y N			
25.1	Y N - LANDFILL			
25.2A	Y N I			
25.2B	Y N I			
25.3	Y N - UNSTABLE SOILS			

FORM B (Cont.)

Evaluation Site: ____________________

		WETLAND CONDITION		COMMENTS/ASSUMPTIONS
Q.#	$\overline{X}$	W	D	
26.1	Y N — LANDFILL [illegible]			
26.2	Y N I — GRNDWTR DISCH			
26.3	Y N I			
27.1	Y N LANDFILL [illegible]			
27.2	Y N I			
27.3	Y N I			

EFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 2 (FIELD)

		WETLAND CONDITION		COMMENTS/ASSUMPTIONS
Q.#	$\overline{X}$	W	D	
28	Y N			
29.1	Y N — [illegible]			
29.2	Y N			
30.	Y N	Y N	Y N	
31.1	Y N	Y N	Y N	
31.2	Y N	Y N	Y N	
31.3	Y N	Y N	Y N	
31.4	Y N I	Y N I	Y N I	Water
31.5	Y N	Y N	Y N	
31.6A	Y N	Y N	Y N	
31.6B	Y N	Y N	Y N	
31.6C	Y N	Y N	Y N	
31.6D	Y N	Y N	Y N	
31.6E	Y N	Y N	Y N	
32A	Y N			
32B	Y N			
32C	Y N			
32D	Y N			
32E	Y N			
32F	Y N			
32G	Y N			
32H	Y N			
32I	Y N			
32J	Y N			
32K	Y N			

FORM B (Cont.)

Evaluation Site: ______________________

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
33A	Y N			
33B	Y N			
33C	Y N			
33D	Y N			
33E	Y N			
33F	Y N			
33G	Y N			
33H	Y N			
33I	Y N			
33J	Y N			
33K	Y N			
34.1	Y N			- DAM >80YRS - ON OLD USGS MAPS
34.2	Y N			
34.3.1	Y N			
34.3.2	Y N I			
35.1	Y N I			
35.2	Y N I			
36.1.1	Y N	Y N	Y N	
36.1.2	Y N	Y N	Y N	
36.2.1	Y N	Y N	Y N	
36.2.2	Y N	Y N	Y N	
36.2.3	Y N	Y N	Y N	
37	Y N			
38.1	Y N			- DAM [illegible] DOWNSTREAM - NONE ABOVE
38.2	Y N			
38.3	Y N			
38.4	Y N			
38.5	Y N			
38.6	Y N			
38.7	Y N			- FLOODPLAIN < 1 mi downstream
38.8	Y N I			
39	Y N			TREES >10" DBH ARE MAST BEARING HARDWD
40.1	Y N I			
40.2	Y N I			
41.1		Y N I		
41.2		Y N I		

FORM B (Cont.)

Evaluation Site: Cold Spring Pond AA-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\overline{X}$	W	D
42.1.1	Y N I	Y N I	Y N I
42.1.2	Y N I	Y N I	Y N I
42.1.3	Y N I	Y N I	Y N I
42.2.1	Y N I	Y N I	Y N I
42.2.2	Y N I	Y N I	Y N I
42.2.3	Y N I	Y N I	Y N I
43A	Y N	Y N	Y N
43B	Y N	Y N	Y N
43C	Y N	Y N	Y N
43D	Y N	Y N	Y N
43E	Y N	Y N	Y N
43F	Y N	Y N	Y N
43G	Y N	Y N	Y N
43H	Y N	Y N	Y N
43I	Y N	Y N	Y N
44A	Y N	Y N	Y N
44B	Y N	Y N	Y N
44C	Y N	Y N	Y N
44D	Y N	Y N	Y N
44E	Y N	Y N	Y N
44F	Y N	Y N	Y N
44G	Y N	Y N	Y N
44H	Y N	Y N	Y N
44I	Y N	Y N	Y N
45A	Y N		
45B	Y N		
45C	Y N		
45D	Y N		
45E	Y N		
45F	Y N		
45G	Y N		
46A	Y N	Y N	Y N
46B	Y N	Y N	Y N
46C	Y N	Y N	Y N
47A	Y N		
47B	Y N		
47C	Y N		

FORM B (Cont.)

Evaluation Site: Cold Spring Pond. AA1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
48A	Y N I	Y N I	Y N I
48B	Y N I	Y N I	Y N I
48C	Y N I	Y N I	Y N I
48D	Y N I	Y N I	Y N I
48E	Y N I	Y N I	Y N I
48F	Y N I	Y N I	Y N I
49.1.1	Y N I	Y N I	Y N I
49.1.2	Y N I	Y N I	Y N I
49.2	Y N I	Y N I	Y N I
49.3	Y N I	Y N I	Y N I
50.	Y N	Y N	Y N

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 3 (DETAILED DATA)

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
51.1	Y N U		
51.2	Y N U		
52.1	Y N I U		
52.2	Y N I U		
53.1	Y N I U		
53.2	Y N I U		
54	Y N U	Y N U	Y N U
55.1	Y N U		
55.2	Y N U		
55.3	Y N U		
55.4	Y N U		
56.1	Y N I U		
56.2	Y N I U		
57.1	Y N U		
57.2	Y N U		
58.	Y N U		

FORM B (Cont.)

Evaluation Site: ______________________________

Q.#	$\overline{X}$	W	D	COMMENTS/ASSUMPTIONS
59.1	Y N I U			
59.2	Y N I U			
60	Y N U			
61	Y N I U			
62	Y N U			
63.1	Y N I U			
63.2	Y N I U			
64		Y N I U		

FORM C: SUPPLEMENTARY OBSERVATIONS

Evaluation Site: GOLD SPRING POND AA#1

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

FISH SPECIES GROUPS*	OBSERVED/REPORTED
1. Warmwater Group	Y or N
2. Coldwater Group	Y or N
3. Northern Lake Group	Y or N
4. Coldwater Riverine Group	Y or N

FISH SPECIES	OBSERVED/REPORTED
22 Yellow Perch 26 Pumpkinseed N	Y or N
10 [illegible]	Y or N
7 Smallmouth Bass	Y or N
40 Redbreasted Sunfish N	

WATERFOWL SPECIES GROUPS**

		OBSERVED/REPORTED		
		NESTING	MIGRATING	WINTERING
1. Prairie Dabblers	110	Y or N	Y or N	Y or N
2. Black Duck	113	Y or N	Y or N	Y or N
3. Wood Duck	116	Y or N	Y or N	Y or N
4. Common and Red-Breasted Mergansers	119	Y or N	Y or N	Y or N
5. Hooded Merganser	122	Y or N	Y or N	Y or N
6. Canvasback, Redhead, Ruddy Duck	125	Y or N	Y or N	Y or N
7. Ring-necked Duck	128	Y or N	Y or N	Y or N
8. Greater and Lesser Scaup	131	Y or N	Y or N	Y or N
9. Common Goldeneye	134	Y or N	Y or N	Y or N
10. Bufflehead	137	Y or N	Y or N	Y or N
11. Whistling Ducks	140	Y or N	Y or N	Y or N
12. Inland Geese	143	Y or N	Y or N	Y or N
13. Tundra Swan	146	Y or N	Y or N	Y or N
14. Brant	149	Y or N	Y or N	Y or N

[illegible]

BIRD SPECIES	OBSERVED/REPORTED
✓ [illegible]	Y or N
✓ [illegible]	Y or N
✓ Green Heron	Y or N

RECREATIONAL ACTIVITIES

Hiking, Birdwatching, Photography, Swimming

Sailing, Power Boating, Canoeing, Kayaking

Snowmobiling, Skiing, Snowshoeing, Ice Skating

Research, Educational Fieldtrips, Horseback Riding

CONSUMPTIVE ACTIVITIES

[illegible]

Agriculture, Hunting

Fur Harvesting, Timber Harvest

Commercial/Sport Fishing, Natural Food Gathering

Peat Harvesting, Water Supply

[illegible]

* Fish species groups are explained on page 138

** Waterfowl species groups are explained on page 1647

FORM D: EVALUATION SUMMARY SHEET

Evaluation Site: ____________________

Wetland Functions and Values

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge			*
Ground Water Discharge			*
Floodflow Alteration			
Sediment Stabilization			*
Sediment/Toxicant Retention			
Nutrient Removal/Transform.			
Production Export	*		*
Wildlife Diversity/Abundance**		*	*
Breeding	*		*
Migration	*		*
Wintering	*		*
Aquatic Diversity/Abundance			*
Uniqueness/Heritage		*	*
Recreation		*	*

Habitat Suitability Evaluation

Fish Species Groups:

__________ Group ___ __________ Group ___ __________ Group ___

Waterfowl Species Groups:

	Breeding	Migration	Wintering
Group ________	___	___	___
Group ________	___	___	___
Group ________	___	___	___
Group ________	___	___	___

Fish, Invertebrate, and Bird Species:

________	___	________	___	________	___
________	___	________	___	________	___
________	___	________	___	________	___
________	___	________	___	________	___

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS
Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).
Is there any evidence that suggests ratings contrary to the above (explain)?

____

Were alternative sources used for any of the ratings above (explain)? ________

____

The loss rate for ____________________ (identify locality/region) between 19__ and 19__ for ____________________ (identify wetland type) was __________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.
** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

WET 2.0

POST PLOW

FORM A: SITE DOCUMENTATION (Page 1 of 2)

Part 1 - Background Information

Evaluation Site: PLOWSHOP POND IA 2 Date: 6/21/93
POST IMPACT - 3 yrs

Site Location (Section, Range, and Township): AYER MA

Has the evaluator taken a training course in WET Version 2.0? Yes

Agencies/Experts Contacted: SCS NOAA

Circle the assessment levels to be completed? SS-1 SS-2 E/O-1&2 E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
Nontidal, Wet Cond - hydrology - March Veget - May Dry Cond - Hydrol - Aug Veg - Nov. Avg Cond - Hydrol - Jan Veg - Sept.

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
No

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? No

Part 2 - Identification and Delineation of Evaluation Areas

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information:

-- Boundaries of the AA, IA, and IZ, and the location of service areas. See Figure
-- Watershed boundaries of AA, and service areas.
-- Extent of surface water in the AA during the wet and dry seasons.
-- Open water (channels and pools) within and adjacent to the AA.
-- Normal direction of channel or tidal flow
-- Normal direction of wind-driven waves or current.
-- Impact area(s).
-- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = N/A acres
Impact Area = ±25 acres (only if applicable)
Watershed of AA = — acres/ ±25 miles^2 (acres x 0.0016 = miles)
Wetlands in AA = ±25 acres
Wetlands in the watershed of closest service area = >500 acres
Wetlands and deepwater in the watershed of closest service area = >500 acres

How were locality and region defined for this evaluation?
locality - Town (Ayer)
Region - State (Massachusetts)

Sketch of Evaluation Areas (or attach map):

See Figure 1.

FORM B: EVALUATION ANSWER SHEET

Evaluation Site: Plowshop Pond I A-2

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

3.1.1 "Red Flags"

				Comments/Assumptions
s1.	Y	N	U	
s2.	Y	N	U	
s3.	Y	N	U	
s4.	Y	N	U	
s5.	Y	N	U	
s6.	Y	N	U	

3.1.2 On-site Social Significance

					Comments/Assumptions
s7.	Y	N	U	I	
s8.	Y	N	U	I	Superfund site

3.1.3 Off-site Social Significance

					Comments
s9.	Y	N	U	I	"Y" s10
s10.	Y	N	U		ch. due to
s11.	Y	N	U		<10% & open
s12.	Y	N	U		until 77%
s13.	Y	N	U		
s14.	Y	N	U		
s15.	Y	N	U	I	
s16.	Y	N	U	I	
s17.	Y	N	U	I	
s18.	Y	N	U	I	
s19.	Y	N	U		
s20.	Y	N	U		

					Comments
s21.	Y	N	U		
s22.	Y	N	U	I	
s23.	Y	N	U		
s24.	Y	N	U		
s25.	Y	N	U		— Superfund
s26.	Y	N	U		No SCEP, no dig.
s27.	Y	N	U		
s28.	Y	N	U		
s29.	Y	N	U		
s30.	Y	N	U		
s31.	Y	N	U		

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
- Standard Density Circle
- Locality
- Hydrologic Unit

Question #			Comments/Assumptions
1	Y	N	Same as 1-1
2	Y	N	
3	Y	N	
4	Y	N	

FORM B (Cont.)

Evaluation Site: Plowshop IA - 2

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 1 (OFFICE)

WETLAND CONDITION | COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
1.1	Y N			
1.2	Y N			
1.3	Y N			
2.1.1	Y N			
2.1.2	Y N			
2.1.3	Y N			
2.2.1	Y N I			
2.2.2	Y N I			
3.1	Y N			
3.2	Y N			
3.3	Y N			
4.1	Y N - Ditch/River [illegible]			
4.2A	Y N			
4.2B	Y N			
4.2C	Y N			
4.2D	Y N			
5.1.1		Y N		
5.1.2		Y N		
5.2		Y N		
6.1	Y N			
6.2	Y N			
7	Y N I			
8.1	Y N			
8.2	Y N			
8.3	Y N			
8.4	Y N			
9.1		Y N		
9.2		Y N I		
9.3		Y N I		
10A	Y N			
10B	Y N			
10C	Y N			
10D	Y N			
10E	Y N			
10F	Y N			

FORM B (Cont.)

Evaluation Site: Plowshop IA-2

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
11	Y N	Y N	Y N
12A	Y N	Y N	Y N
12Aa	Y N	Y N	Y N
12Ab	Y N	Y N	Y N
12Ac	Y N	Y N	Y N
12Ad	Y N	Y N	Y N
12Ae	Y N	Y N	Y N
12B	Y N	Y N	Y N
12Ba	Y N	Y N	Y N
12Bb	Y N	Y N	Y N
12Bc	Y N	Y N	Y N
12Bd	Y N	Y N	Y N
12Be	Y N	Y N	Y N
12C	Y N	Y N	Y N
12Ca	Y N	Y N	Y N
12Cb	Y N	Y N	Y N
12Cc	Y N	Y N	Y N
12Cd	Y N	Y N	Y N
12D	Y N	Y N	Y N
12Da	Y N	Y N	Y N
12Db	Y N	Y N	Y N
12E	Y N	Y N	Y N
13A	Y N	Y N	Y N
13Aa	Y N	Y N	Y N
13Ab	Y N	Y N	Y N
13Ac	Y N	Y N	Y N
13Ad	Y N	Y N	Y N
13Ae	Y N	Y N	Y N
13B	Y N	Y N	Y N
13Ba	Y N	Y N	Y N
13Bb	Y N	Y N	Y N
13Bc	Y N	Y N	Y N
13Bd	Y N	Y N	Y N
13Be	Y N	Y N	Y N
13C	Y N	Y N	Y N
13Ca	Y N	Y N	Y N
13Cb	Y N	Y N	Y N
13Cc	Y N	Y N	Y N
13Cd	Y N	Y N	Y N
13D	Y N	Y N	Y N
13Da	Y N	Y N	Y N
13Db	Y N	Y N	Y N
13E	Y N	Y N	Y N

FORM B (Cont.)

Evaluation Site: Plowshop IA-7

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
14.1	Y N	Y N	Y N
14.2	Y N	Y N	Y N
15.1A	Y N I		
15.1B	Y N I		
15.1C	Y N I		
15.2	Y N I		
16A	Y N	Y N	Y N
16B	Y N	Y N	Y N
16C	Y N	Y N	Y N
17	Y N		
18	Y N I		
19.1A	Y N I		
19.1B	Y N I		
19.2	Y N I		
19.3	Y N I		
20.1	Y N I		
20.2	Y N I		
21A	Y N		
21B	Y N		
21C	Y N		
21D	Y N		
21E	Y N		
22.1.1	Y N		
22.1.2	Y N I		
22.2	Y N		
22.3	Y N I		
23	Y N		
24.1	Y N I		
24.2	Y N I		
24.3	Y N I		
24.4	Y N I		
24.5	Y N		
25.1	Y N		
25.2A	Y N I		
25.2B	Y N I		
25.3	Y N		

Evaluation Site: Cold Spring IA-2

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
26.1	Y N		
26.2	Y N I		
26.3	Y N I		
27.1	Y N		
27.2	Y N I		
27.3	Y N I		

EFFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 2 (FIELD)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
28	Y N		
29.1	Y N		
29.2	Y N		
30.	Y N	Y N	Y N
31.1	Y N	Y N	Y N
31.2	Y N	Y N	Y N
31.3	Y N	Y N	Y N
31.4	Y N I	Y N I	Y N I
31.5	Y N	Y N	Y N
31.6A	Y N	Y N	Y N
31.6B	Y N	Y N	Y N
31.6C	Y N	Y N	Y N
31.6D	Y N	Y N	Y N
31.6E	Y N	Y N	Y N
32A	Y N		
32B	Y N		
32C	Y N		
32D	Y N		
32E	Y N		
32F	Y N		
32G	Y N		
32H	Y N		
32I	Y N		
32J	Y N		
32K	Y N		

FORM B (Cont.)

Evaluation Site: Plowshop I + 2

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
42.1.1	Y N I	Y N I	Y N I
42.1.2	Y N I	Y N I	Y N I
42.1.3	Y N I	Y N I	Y N I
42.2.1	Y N I	Y N I	Y N I
42.2.2	Y N I	Y N I	Y N I
42.2.3	Y N I	Y N I	Y N I
43A	Y N	Y N	Y N
43B	Y N	Y N	Y N
43C	Y N	Y N	Y N
43D	Y N	Y N	Y N
43E	Y N	Y N	Y N
43F	Y N	Y N	Y N
43G	Y N	Y N	Y N
43H	Y N	Y N	Y N
43I	Y N	Y N	Y N
44A	Y N	Y N	Y N
44B	Y N	Y N	Y N
44C	Y N	Y N	Y N
44D	Y N	Y N	Y N
44E	Y N	Y N	Y N
44F	Y N	Y N	Y N
44G	Y N	Y N	Y N
44H	Y N	Y N	Y N
44I	Y N	Y N	Y N
45A	Y N		
45B	Y N		
45C	Y N		
45D	Y N	– assumed [illegible] [illegible] in maj. of area	
45E	Y N		
45F	Y N		
45G	Y N		
46A	Y N	Y N	Y N
46B	Y N	Y N	Y N
46C	Y N	Y N	Y N
47A	Y N		
47B	Y N		
47C	Y N		

FORM B (Cont.)

Evaluation Site: PlowShop AA2

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	X̄	W	D
48A	Y N I	Y N I	Y N I
48B	Y N I	Y N I	Y N I
48C	Y N I	Y N I	Y N I
48D	Y N I	Y N I	Y N I
48E	Y N I	Y N I	Y N I
48F	Y N I	Y N I	Y N I
49.1.1	Y N I	Y N I	Y N I
49.1.2	Y N I	Y N I	Y N I
49.2	Y N I	Y N I	Y N I
49.3	Y N I	Y N I	Y N I
50.	Y N	Y N	Y N

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 3 (DETAILED DATA)

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	X̄	W	D
51.1	Y N U		
51.2	Y N U		
52.1	Y N I U		
52.2	Y N I U		
53.1	Y N I U		
53.2	Y N I U		
54	Y N U	Y N U	Y N U
55.1	Y N U		
55.2	Y N U		
55.3	Y N U		
55.4	Y N U		
56.1	Y N I U		
56.2	Y N I U		
57.1	Y N U		
57.2	Y N U		
58.	Y N U		

Evaluation Site: ______________________________

	WETLAND CONDITION			COMMENTS/ASSUMPTIONS
Q.#	$\overline{X}$	W	D	
59.1	Y N I U			
59.2	Y N I U			
60	Y N U			
61	Y N I U			
62	Y N U			
63.1	Y N I U			
63.2	Y N I U			
64		Y N I U		

FORM C: SUPPLEMENTARY OBSERVATIONS

Evaluation Site: ______________________________

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

FISH SPECIES GROUPS*	OBSERVED/REPORTED
1. Warmwater Group	Y or N
2. Coldwater Group	Y or N
3. Northern Lake Group	Y or N
4. Coldwater Riverine Group	Y or N

FISH SPECIES	OBSERVED/REPORTED
______________________	Y or N
______________________	Y or N
______________________	Y or N

WATERFOWL SPECIES GROUPS**	OBSERVED/REPORTED		
	NESTING	MIGRATING	WINTERING
1. Prairie Dabblers	Y or N	Y or N	Y or N
2. Black Duck	Y or N	Y or N	Y or N
3. Wood Duck	Y or N	Y or N	Y or N
4. Common and Red-Breasted Mergansers	Y or N	Y or N	Y or N
5. Hooded Merganser	Y or N	Y or N	Y or N
6. Canvasback, Redhead, Ruddy Duck	Y or N	Y or N	Y or N
7. Ring-necked Duck	Y or N	Y or N	Y or N
8. Greater and Lesser Scaup	Y or N	Y or N	Y or N
9. Common Goldeneye	Y or N	Y or N	Y or N
10. Bufflehead	Y or N	Y or N	Y or N
11. Whistling Ducks	Y or N	Y or N	Y or N
12. Inland Geese	Y or N	Y or N	Y or N
13. Tundra Swan	Y or N	Y or N	Y or N
14. Brant	Y or N	Y or N	Y or N

BIRD SPECIES	OBSERVED/REPORTED
______________________	Y or N
______________________	Y or N
______________________	Y or N

RECREATIONAL ACTIVITIES

Hiking	Sailing	Snowmobiling	Research
Birdwatching	Power Boating	Skiing	Educational Fieldtrips
Photography	Canoeing	Snowshoeing	Horseback Riding
Swimming	Kayaking	Ice Skating	

CONSUMPTIVE ACTIVITIES

Agriculture	Fur Harvesting	Commercial/Sport Fishing	Peat Harvesting
Hunting	Timber Harvest	Natural Food Gathering	Water Supply

* Fish species groups are explained on page 138
** Waterfowl species groups are explained on page 1647

FORM D: EVALUATION SUMMARY SHEET

Evaluation Site: ____________________

Wetland Functions and Values

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge			*
Ground Water Discharge			*
Floodflow Alteration			
Sediment Stabilization			*
Sediment/Toxicant Retention			
Nutrient Removal/Transform.			
Production Export	*		*
Wildlife Diversity/Abundance**		*	*
Breeding	*		*
Migration	*		*
Wintering	*		*
Aquatic Diversity/Abundance			*
Uniqueness/Heritage		*	*
Recreation		*	*

Habitat Suitability Evaluation

Fish Species Groups:

________ Group ___ ________ Group ___ ________ Group ___

Waterfowl Species Groups:

	Breeding	Migration	Wintering
Group ________	___	___	___
Group ________	___	___	___
Group ________	___	___	___
Group ________	___	___	___

Fish, Invertebrate, and Bird Species:

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS
Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).
Is there any evidence that suggests ratings contrary to the above (explain)?

Were alternative sources used for any of the ratings above (explain)? ________

The loss rate for ____________________ (identify locality/region) between 19__ and 19__ for ____________________ (identify wetland type) was __________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.
** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

DATA NAME: PLOWSHOP

FORM A: SITE DOCUMENTATION (Page 1 of 2)

Part 1 - Background Information AA2

Evaluation Site: PLOWSHOP POND-EXIST. Date: 6-18-93

Site Location (Section, Range, and Township): AYER, MA.

Has the evaluator taken a training course in WET Version 2.0? YES

Agencies/Experts Contacted: SCS NOAA MA DF+W

Circle the assessment levels to be completed? SS-1 SS-2 E/O-1&2 E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
NONTIDAL - WET CONDITIONS - HYDROLOGY - MARCH, VEGET.
MAY, DRY COND. - HYDROLOGY - AUG., VEGETATION - NOV. +
AVG COND - HYDROL - JUNE, VEG - SEPT.

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
NO

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? NO

Part 2 - Identification and Delineation of Evaluation Areas

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information:

-- Boundaries of the AA, IA, and IZ, and the location of service areas. (See Figure
-- Watershed boundaries of AA, and service areas.
-- Extent of surface water in the AA during the wet and dry seasons.
-- Open water (channels and pools) within and adjacent to the AA.
-- Normal direction of channel or tidal flow
-- Normal direction of wind-driven waves or current.
-- Impact area(s).
-- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = ± 25 acres
Impact Area = N/A acres (only if applicable)
Watershed of AA = — acres/ ±25 miles^2 (acres x 0.0016 = miles)
Wetlands in AA = ±25 acres
Wetlands in the watershed of closest service area = >500 acres
Wetlands and deepwater in the watershed of closest service area = >500 acres

How were locality and region defined for this evaluation?
Locality – Town (AYER)
Region – State (Massachusetts)

Sketch of Evaluation Areas (or attach map):

See Figure 1

FORM B: EVALUATION ANSWER SHEET

Evaluation Site: PLOWSHOP POND AA2

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

3.1.1 "Red Flags"

Comments/Assumptions

s1. Y N U - NOT LISTED BY MA. NATURAL HERITAGE
s2. Y N U
s3. Y N U
s4. Y N U
s5. Y N U
s6. Y N U

3.1.2 On-site Social Significance

Comments/Assumptions

s7. Y N U I
s8. Y N U I - SUPERFUND SITE ADJ. PLOWSHOP POND

3.1.3 Off-site Social Significance

Comments

s9. Y N U I
s10. Y N U - "Y" changed to "N" because: (1) <15% [illegible] wetland (2) wetl44 >7%
s11. Y N U
s12. Y N U
s13. Y N U
s14. Y N U MA.
s15. Y N U I - NAT. HER.
s16. Y N U I - GROVE POND WELL FIELD
s17. Y N U I
s18. Y N U I
s19. Y N U - [illegible]
s20. Y N U

Comments

s21. Y N U - PLACE [illegible], WOOD [illegible]
s22. Y N U I
s23. Y N U
s24. Y N U
s25. Y N U - SUPERFUND SITE
s26. Y N U
s27. Y N U - [illegible]
s28. Y N U
s29. Y N U - MILITARY [illegible]
s30. Y N U
s31. Y N U - NOW [illegible]

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
Standard Density Circle
Locality
Hydrologic Unit

Question #

Comments/Assumptions

1 Y N - [illegible]
2 Y N - SAME AS [illegible] POND [illegible] AREA
3 Y N - [illegible] GROVE POND SAME
4 Y N - FLOOD [illegible] YEAR ZONE [illegible]

FORM B (Cont.)

Evaluation Site: • PLOWSHOP POND - FT. DEVENS, AYER, MA

AAZ

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 1 (OFFICE)

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
1.1	Y N			
1.2	Y N			– EROSIVITY FACTOR 125-SCS
1.3	Y N			
2.1.1	Y N			
2.1.2	Y N			
2.1.3	Y N			
2.2.1	Y N I			
2.2.2	Y N I			- USGS TOPO + FIELD OBS.
3.1	Y N			
3.2	Y N			NWI MAP
3.3	Y N			
4.1	Y N			- NASHUA/MERRIMACK > 100 mi
4.2A	Y N			
4.2B	Y N			
4.2C	Y N			
4.2D	Y N			
5.1.1		Y N		~3%
5.1.2		Y N		
5.2		Y N		– [illegible]
6.1	Y N			
6.2	Y N			
7	Y N I			
8.1	Y N			
8.2	Y N			
8.3	Y N			
8.4	Y N			
9.1		Y N		– constr. outlet – a & c true
9.2		Y N I		
9.3		Y N I		
10A	Y N			
10B	Y N			
10C	Y N			
10D	Y N			
10E	Y N			
10F	Y N			

Table header: WETLAND CONDITION (over $\bar{X}$, W, D)

FORM B (Cont.)

Evaluation Site: PLOWSHOP POND AA-2

WETLAND CONDITION

Q.#	$\bar{X}$	W	D
11	Y N	Y N	Y N
12A	Y N	Y N	Y N
12Aa	Y N	Y N	Y N
12Ab	Y N	Y N	Y N
12Ac	Y N	Y N	Y N
12Ad	Y N	Y N	Y N
12Ae	Y N	Y N	Y N
12B	Y N	Y N	Y N
12Ba	Y N	Y N	Y N
12Bb	Y N	Y N	Y N
12Bc	Y N	Y N	Y N
12Bd	Y N	Y N	Y N
12Be	Y N	Y N	Y N
12C	Y N	Y N	Y N
12Ca	Y N	Y N	Y N
12Cb	Y N	Y N	Y N
12Cc	Y N	Y N	Y N
12Cd	Y N	Y N	Y N
12D	Y N	Y N	Y N
12Da	Y N	Y N	Y N
12Db	Y N	Y N	Y N
12E	Y N	Y N	Y N
13A	Y N	Y N	Y N
13Aa	Y N	Y N	Y N
13Ab	Y N	Y N	Y N
13Ac	Y N	Y N	Y N
13Ad	Y N	Y N	Y N
13Ae	Y N	Y N	Y N
13B	Y N	Y N	Y N
13Ba	Y N	Y N	Y N
13Bb	Y N	Y N	Y N
13Bc	Y N	Y N	Y N
13Bd	Y N	Y N	Y N
13Be	Y N	Y N	Y N
13C	Y N	Y N	Y N
13Ca	Y N	Y N	Y N
13Cb	Y N	Y N	Y N
13Cc	Y N	Y N	Y N
13Cd	Y N	Y N	Y N
13D	Y N	Y N	Y N
13Da	Y N	Y N	Y N
13Db	Y N	Y N	Y N
13E	Y N	Y N	Y N

COMMENTS/ASSUMPTIONS

Dominant AA - AQUATIC BED, ROOTED VASCULAR

EDGE B - BROAD LEAVED DECIDUOUS

C - AQUATIC BED ROOTED VASCULAR

>10% - AQUATIC BED

>1 ACRE - SHRUB/SCRUB ALONG SHORELINE

FORM B (Cont.)

Evaluation Site: PLOWSHOP POND AAZ

Q.#	$\overline{X}$	W	D	COMMENTS/ASSUMPTIONS
		WETLAND CONDITION		
14.1	Y N	Y N	Y N	- NONE OBSERVED
14.2	Y N	Y N	Y N	
15.1A	Y N I			
15.1B	Y N I			
15.1C	Y N I			
15.2	Y N I			NO CHANNEL [illegible]
16A	Y N	Y N	Y N	PEEPON AQUATIC [illegible]
16B	Y N	Y N	Y N	
16C	Y N	Y N	Y N	
17	Y N			>70% AQUATIC [illegible] OVER ~30 ACRES
18	Y N I			REGULAR W/Z [illegible]
19.1A	Y N I - 22 [illegible], LAND [illegible] TOPO [illegible]			
19.1B	Y N I			
19.2	Y N I			
19.3	Y N I - VEG OF A.A. [illegible]			
20.1	Y N I			
20.2	Y N I			
21A	Y N [illegible]			
21B	Y N			
21C	Y N			
21D	Y N			
21E	Y N			
22.1.1	Y N			
22.1.2	Y N I			
22.2	Y N			
22.3	Y N I			
23	Y N DAM SLOWS [illegible]			
24.1	Y N I - SEE SOIL MAPS			
24.2	Y N I			
24.3	Y N I			
24.4	Y N I -			
24.5	Y N			
25.1	Y N - LANDFILL			
25.2A	Y N I			
25.2B	Y N I			
25.3	Y N - UNSTABLE SANDY SOILS			

Evaluation Site: ______________________

Q.#	WETLAND CONDITION $\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
26.1	Y N — LANDFILL			
26.2	Y N I — BENDWTR DISCH			
26.3	Y N I			
27.1	Y N LANDFILL			
27.2	Y N I			
27.3	Y N I			

EFFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 2 (FIELD)

Q.#	WETLAND CONDITION $\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
28	Y N			
29.1	Y N —			
29.2	Y N			
30.	Y N	Y N	Y N	
31.1	Y N	Y N	Y N	
31.2	Y N	Y N	Y N	
31.3	Y N	Y N	Y N	
31.4	Y N I	Y N I	Y N I	
31.5	Y N	Y N	Y N	
31.6A	Y N	Y N	Y N	
31.6B	Y N	Y N	Y N	
31.6C	Y N	Y N	Y N	
31.6D	Y N	Y N	Y N	
31.6E	Y N	Y N	Y N	
32A	Y N			
32B	Y N			
32C	Y N			
32D	Y N			
32E	Y N			
32F	Y N			
32G	Y N			
32H	Y N			
32I	Y N			
32J	Y N			
32K	Y N			

Evaluation Site: ______________________________

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
33A	Y N			
33B	Y N			
33C	Y N			
33D	Y N			
33E	Y N			
33F	Y N			
33G	Y N			
33H	Y N			
33I	Y N			
33J	Y N			
33K	Y N			
34.1	Y N			- DAM 720YDS - ON OLD USGS MAPS
34.2	Y N			
34.3.1	Y N			
34.3.2	Y N I			
35.1	Y N I			
35.2	Y N I			
36.1.1	Y N	Y N	Y N	
36.1.2	Y N	Y N	Y N	
36.2.1	Y N	Y N	Y N	
36.2.2	Y N	Y N	Y N	
36.2.3	Y N	Y N	Y N	
37	Y N			
38.1	Y N			- DAM ELIM. DOWNSTREAM - NONE ABOVE
38.2	Y N			
38.3	Y N			
38.4	Y N			
38.5	Y N			
38.6	Y N			
38.7	Y N			- FLOODPLAIN < 1 mi downstream
38.8	Y N I			
39	Y N			TREES > 10" DBH AND MAST BEARING HARDWOOD
40.1	Y N I			
40.2	Y N I			
41.1		Y N I		
41.2		Y N I		

Evaluation Site: ______________________________

WETLAND CONDITION

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
42.1.1	Y N I	Y N I	Y N I	
42.1.2	Y N I	Y N I	Y N I	
42.1.3	Y N I	Y N I	Y N I	
42.2.1	Y N I	Y N I	Y N I	Downstream River
42.2.2	Y N I	Y N I	Y N I	– inaccess. to fish
42.2.3	Y N I	Y N I	Y N I	due to DAM.
43A	Y N	Y N	Y N	
43B	Y N	Y N	Y N	
43C	Y N	Y N	Y N	
43D	Y N	Y N	Y N	
43E	Y N	Y N	Y N	– Ecol. Envir. Report
43F	Y N	Y N	Y N	pg 3-70 4/95
43G	Y N	Y N	Y N	
43H	Y N	Y N	Y N	
43I	Y N	Y N	Y N	
44A	Y N	Y N	Y N	
44B	Y N	Y N	Y N	
44C	Y N	Y N	Y N	
44D	Y N	Y N	Y N	Field observ.
44E	Y N	Y N	Y N	of aquatics
44F	Y N	Y N	Y N	
44G	Y N	Y N	Y N	
44H	Y N	Y N	Y N	
44I	Y N	Y N	Y N	
45A	Y N			
45B	Y N			
45C	Y N			
45D	Y N			
45E	Y N			
45F	Y N			
45G	Y N			
46A	Y N	Y N	Y N	
46B	Y N	Y N	Y N	
46C	Y N	Y N	Y N	
47A	Y N			
47B	Y N			
47C	Y N	ESL 8/91		

Evaluation Site: ______________________________

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
48A	Y N I	Y N I	Y N I	
48B	Y N I	Y N I	Y N I	
48C	Y N I	Y N I	Y N I	
48D	Y N I	Y N I	Y N I	
48E	Y N I	Y N I	Y N I	
48F	Y N I	Y N I	Y N I	
49.1.1	Y N I	Y N I	Y N I	- DAM IMPOUNDED
49.1.2	Y N I	Y N I	Y N I	
49.2	Y N I	Y N I	Y N I	
49.3	Y N I	Y N I	Y N I	
50.	Y N	Y N	Y N	RICH DIVERSITY

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 3 (DETAILED DATA)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
51.1	Y N U			
51.2	Y N U			
52.1	Y N I U			
52.2	Y N I U			
53.1	Y N I U			
53.2	Y N I U			
54	Y N U	Y N U	Y N U	
55.1	Y N U			
55.2	Y N U			
55.3	Y N U			
55.4	Y N U			
56.1	Y N I U			
56.2	Y N I U			
57.1	Y N U			
57.2	Y N U			
58.	Y N U			

FORM B (Cont.)

Evaluation Site: ______________________________

Q.#	WETLAND CONDITION $\bar{X}$	W	D	COMMENTS/ASSUMPTIONS
59.1	Y N I U			
59.2	Y N I U			
60	Y N U			
61	Y N I U			
62	Y N U			
63.1	Y N I U			
63.2	Y N I U			
64		Y N I U		

FORM C: SUPPLEMENTARY OBSERVATIONS

Evaluation Site: AA2 Plowshop Pond

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

FISH SPECIES GROUPS*	OBSERVED/REPORTED
1. Warmwater Group	Y or N
2. Coldwater Group	Y or N
3. Northern Lake Group	Y or N
4. Coldwater Riverine Group	Y or N

FISH SPECIES	OBSERVED/REPORTED
[illegible]	Y or N
BLUE GILL	Y or N
Y. PERCH	Y or N

WATERFOWL SPECIES GROUPS**	OBSERVED/REPORTED NESTING	MIGRATING	WINTERING
1. Prairie Dabblers	Y or N	Y or N	Y or N
2. Black Duck	Y or N	Y or N	Y or N
3. Wood Duck	Y or N	117 Y or N	119 Y or N
4. Common and Red-Breasted Mergansers	119 Y or N	Y or N	Y or N
5. Hooded Merganser	122 Y or N	Y or N	Y or N
6. Canvasback, Redhead, Ruddy Duck	125 Y or N	Y or N	Y or N
7. Ring-necked Duck	128 Y or N	Y or N	Y or N
8. Greater and Lesser Scaup	131 Y or N	Y or N	Y or N
9. Common Goldeneye	134 Y or N	Y or N	Y or N
10. Bufflehead	137 Y or N	Y or N	Y or N
11. Whistling Ducks	140 Y or N	Y or N	Y or N
12. Inland Geese	143 Y or N	Y or N	Y or N
13. Tundra Swan	146 Y or N	Y or N	Y or N
14. Brant	149 Y or N	Y or N	Y or N

best judgement very little data available on actual waterfowl use of this pond.

BIRD SPECIES	OBSERVED/REPORTED
Double-crested Cormorant (fish-eater)	Y or N
208 Belted KINGFISHER	Y or N
249 SPOTTED SANDPIPER	Y or N

Tree swallow 284

RECREATIONAL ACTIVITIES

Hiking
Birdwatching
Photography
Swimming
Sailing
Power Boating
Canoeing
Kayaking
Snowmobiling
Skiing
Snowshoeing
Ice Skating
Research
Educational Fieldtrips
Horseback Riding

CONSUMPTIVE ACTIVITIES

Agriculture
Hunting
shotgun shells found in water
Fur Harvesting
Timber Harvest
Commercial/Sport Fishing
catch + release only
Natural Food Gathering
Peat Harvesting
Water Supply

* Fish species groups are explained on page 138
** Waterfowl species groups are explained on page 1647

FORM D: EVALUATION SUMMARY SHEET

Evaluation Site: ______________________________

Wetland Functions and Values

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge			*
Ground Water Discharge			*
Floodflow Alteration			
Sediment Stabilization			*
Sediment/Toxicant Retention			
Nutrient Removal/Transform.			
Production Export	*		*
Wildlife Diversity/Abundance**		*	*
Breeding	*		*
Migration	*		*
Wintering	*		*
Aquatic Diversity/Abundance			*
Uniqueness/Heritage		*	*
Recreation		*	*

Habitat Suitability Evaluation

Fish Species Groups:

______________ Group ___ ______________ Group ___ ______________ Group ___

Waterfowl Species Groups:

	Breeding	Migration	Wintering
Group ______________	___	___	___
Group ______________	___	___	___
Group ______________	___	___	___
Group ______________	___	___	___

Fish, Invertebrate, and Bird Species:

______________ ___ ______________ ___ ______________ ___
______________ ___ ______________ ___ ______________ ___
______________ ___ ______________ ___ ______________ ___
______________ ___ ______________ ___ ______________ ___

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS
Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).
Is there any evidence that suggests ratings contrary to the above (explain)?
____
Were alternative sources used for any of the ratings above (explain)? ______________
____
The loss rate for ______________________ (identify locality/region) between 19__ and 19__ for ______________________ (identify wetland type) was ______________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.
** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

POST COLD

FORM A: SITE DOCUMENTATION (Page 1 of 2)

Part 1 - Background Information

Evaluation Site: COLD SPRING POND IA 1 Date: 6/21/93
POST-IMPACT - 3 yrs

Site Location (Section, Range, and Township): AYER, MA

Has the evaluator taken a training course in WET Version 2.0? YES

Agencies/Experts Contacted: SCS NOAA MA DF+W

Circle the assessment levels to be completed? SS-1 SS-2 E/O-1&2 E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
NONTIDAL. Wet Cond - hydr - March veg - May Dry Cond - Hydrol - Aug veg - Nov + N, Avg Cond - Hydrol - June Veg. Sept

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
NO

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? NO

Part 2 - Identification and Delineation of Evaluation Areas

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information: SEE FIGURE 1

-- Boundaries of the AA, IA, and IZ, and the location of service areas.
-- Watershed boundaries of AA, and service areas.
-- Extent of surface water in the AA during the wet and dry seasons.
-- Open water (channels and pools) within and adjacent to the AA.
-- Normal direction of channel or tidal flow
-- Normal direction of wind-driven waves or current.
-- Impact area(s).
-- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = N/A acres
Impact Area = ± 3 acres (only if applicable)
Watershed of AA = ± 50 acres/ 0.08 miles^2 (acres x 0.0016 = miles)
Wetlands in AA = ± 3 acres
Wetlands in the watershed of closest service area = >500 acres
Wetlands and deepwater in the watershed of closest service area = >500 acres

How were locality and region defined for this evaluation?
locality - Town
Region - State

Sketch of Evaluation Areas (or attach map):

See Figure 1

FORM B: EVALUATION ANSWER SHEET

Evaluation Site: Cold Spring Pond I A-1

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

3.1.1 "Red Flags"

Comments/Assumptions

s1. Y N U
s2. Y N U
s3. Y N U
s4. Y N U
s5. Y N U
s6. Y N U

3.1.2 On-site Social Significance

Comments/Assumptions

s7. Y N U I
s8. Y N U I — Superfund site

3.1.3 Off-site Social Significance

		Comments
s9.	Y N U I	"Y"
s10.	Y N U	s10
s11.	Y N U	Ch. due to
s12.	Y N U	<10% impr.
s13.	Y N U	open water >7%
s14.	Y N U	
s15.	Y N U I	
s16.	Y N U I	
s17.	Y N U I	
s18.	Y N U I	
s19.	Y N U	
s20.	Y N U	

		Comments
s21.	Y N U	
s22.	Y N U I	
s23.	Y N U	
s24.	Y N U	
s25.	Y N U	-Superfund
s26.	Y N U	No SCORP, no def
s27.	Y N U	
s28.	Y N U	
s29.	Y N U	
s30.	Y N U	
s31.	Y N U	

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)

Standard Density Circle
Locality
Hydrologic Unit

Question #

Comments/Assumptions

1 Y N
2 Y N
3 Y N
4 Y N

Same as 1A

FORM B (Cont.)

Evaluation Site: Cold Spring IA-1

EFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 1 (OFFICE)

Q.#	$\overline{X}$	W	D	COMMENTS/ASSUMPTIONS
		WETLAND CONDITION		
1.1	Y N			
1.2	Y N			
1.3	Y N			
2.1.1	Y N			
2.1.2	Y N			
2.1.3	Y N			
2.2.1	Y N I			
2.2.2	Y N I			
3.1	Y N			
3.2	Y N			
3.3	Y N			
4.1	Y N Near/Near River			
4.2A	Y N			
4.2B	Y N			
4.2C	Y N			
4.2D	Y N			
5.1.1		Y N		
5.1.2		Y N		
5.2		Y N		
6.1	Y N			
6.2	Y N			
7	Y N I			
8.1	Y N			
8.2	Y N			
8.3	Y N			
8.4	Y N			
9.1		Y N		
9.2		Y N I		
9.3		Y N I		
10A	Y N			
10B	Y N			
10C	Y N			
10D	Y N			
10E	Y N			
10F	Y N			

FORM B (Cont.)

Evaluation Site: Cold Sp I-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
11	Y N	Y N	Y N
12A	Y N	Y N	Y N
12Aa	Y N	Y N	Y N
12Ab	Y N	Y N	Y N
12Ac	Y N	Y N	Y N
12Ad	Y N	Y N	Y N
12Ae	Y N	Y N	Y N
12B	Y N	Y N	Y N
12Ba	Y N	Y N	Y N
12Bb	Y N	Y N	Y N
12Bc	Y N	Y N	Y N
12Bd	Y N	Y N	Y N
12Be	Y N	Y N	Y N
12C	Y N	Y N	Y N
12Ca	Y N	Y N	Y N
12Cb	Y N	Y N	Y N
12Cc	Y N	Y N	Y N
12Cd	Y N	Y N	Y N
12D	Y N	Y N	Y N
12Da	Y N	Y N	Y N
12Db	Y N	Y N	Y N
12E	Y N	Y N	Y N
13A	Y N	Y N	Y N
13Aa	Y N	Y N	Y N
13Ab	Y N	Y N	Y N
13Ac	Y N	Y N	Y N
13Ad	Y N	Y N	Y N
13Ae	Y N	Y N	Y N
13B	Y N	Y N	Y N
13Ba	Y N	Y N	Y N
13Bb	Y N	Y N	Y N
13Bc	Y N	Y N	Y N
13Bd	Y N	Y N	Y N
13Be	Y N	Y N	Y N
13C	Y N	Y N	Y N
13Ca	Y N	Y N	Y N
13Cb	Y N	Y N	Y N
13Cc	Y N	Y N	Y N
13Cd	Y N	Y N	Y N
13D	Y N	Y N	Y N
13Da	Y N	Y N	Y N
13Db	Y N	Y N	Y N
13E	Y N	Y N	Y N

FORM B (Cont.)

Evaluation Site: Cold Springs IA-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\bar{X}$	W	D
14.1	Y N	Y N	Y N
14.2	Y N	Y N	Y N
15.1A	Y N I		
15.1B	Y N I		
15.1C	Y N I		
15.2	Y N I		
16A	Y N	Y N	Y N
16B	Y N	Y N	Y N
16C	Y N	Y N	Y N
17	Y N		
18	Y N I		
19.1A	Y N I		
19.1B	Y N I		
19.2	Y N I		
19.3	Y N I		
20.1	Y N I		
20.2	Y N I		
21A	Y N		
21B	Y N		
21C	Y N		
21D	Y N		
21E	Y N		
22.1.1	Y N		
22.1.2	Y N I		
22.2	Y N		
22.3	Y N I		
23	Y N		
24.1	Y N I		
24.2	Y N I		
24.3	Y N I		
24.4	Y N I		
24.5	Y N		
25.1	Y N		
25.2A	Y N I		
25.2B	Y N I		
25.3	Y N		

FORM B (Cont.)

Evaluation Site: Cold Spring I-A-1

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\overline{X}$	W	D
26.1	Y N		
26.2	Y N I		
26.3	Y N I		
27.1	Y N		
27.2	Y N I		
27.3	Y N I		

EFFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 2 (FIELD)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

Q.#	$\overline{X}$	W	D
28	Y N		
29.1	Y N		
29.2	Y N		
30.	Y N	Y N	Y N
31.1	Y N	Y N	Y N
31.2	Y N	Y N	Y N
31.3	Y N	Y N	Y N
31.4	Y N I	Y N I	Y N I
31.5	Y N	Y N	Y N
31.6A	Y N	Y N	Y N
31.6B	Y N	Y N	Y N
31.6C	Y N	Y N	Y N
31.6D	Y N	Y N	Y N
31.6E	Y N	Y N	Y N
32A	Y N		
32B	Y N		
32C	Y N		
32D	Y N		
32E	Y N		
32F	Y N		
32G	Y N		
32H	Y N		
32I	Y N		
32J	Y N		
32K	Y N		

FORM B (Cont.)

Evaluation Site: Cold Spring IA-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\overline{X}$	W	D
33A	Y N		
33B	Y N		
33C	Y N		
33D	Y N		
33E	Y N		
33F	Y N		
33G	Y N		
33H	Y N		
33I	Y N		
33J	Y N		
33K	Y N		
34.1	Y N		
34.2	Y N		
34.3.1	Y N		
34.3.2	Y N I		
35.1	Y N I		
35.2	Y N I		
36.1.1	Y N	Y N	Y N
36.1.2	Y N	Y N	Y N
36.2.1	Y N	Y N	Y N
36.2.2	Y N	Y N	Y N
36.2.3	Y N	Y N	Y N
37	Y N		
38.1	Y N		
38.2	Y N		
38.3	Y N		
38.4	Y N		
38.5	Y N		
38.6	Y N		
38.7	Y N		
38.8	Y N I		
39	Y N		
40.1	Y N I		
40.2	Y N I		
41.1		Y N I	
41.2		Y N I	

FORM B (Cont.)

Evaluation Site: Cold Springs   I A-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

Q.#	$\overline{X}$	W	D
42.1.1	Y N I	Y N I	Y N I
42.1.2	Y N I	Y N I	Y N I
42.1.3	Y N I	Y N I	Y N I
42.2.1	Y N I	Y N I	Y N I
42.2.2	Y N I	Y N I	Y N I
42.2.3	Y N I	Y N I	Y N I
43A	Y N	Y N	Y N
43B	Y N	Y N	Y N
43C	Y N	Y N	Y N
43D	Y N	Y N	Y N
43E	Y N	Y N	Y N
43F	Y N	Y N	Y N
43G	Y N	Y N	Y N
43H	Y N	Y N	Y N
43I	Y N	Y N	Y N
44A	Y N	Y N	Y N
44B	Y N	Y N	Y N
44C	Y N	Y N	Y N
44D	Y N	Y N	Y N
44E	Y N	Y N	Y N
44F	Y N	Y N	Y N
44G	Y N	Y N	Y N
44H	Y N	Y N	Y N
44I	Y N	Y N	Y N
45A	Y N		
45B	Y N	see [illegible]	
45C	Y N		
45D	Y N		
45E	Y N		
45F	Y N		
45G	Y N		
46A	Y N	Y N	Y N
46B	Y N	Y N	Y N
46C	Y N	Y N	Y N
47A	Y N		
47B	Y N		
47C	Y N		

****

Habitat Suitability Evaluation Results for "plowshop"

****

Species/Group	Rating	Observed
Warmwater Fish Group	H	y
Warmwater Fish Group	H	y
Warmwater Fish Group	H	y
Northern Lake Fish Group	H	y
Coldwater Fish Group	L	n
Coldwater Riverine Fish Group	L	n
Waterfowl Group 1 (Breeding)	L	y
Waterfowl Group 1 (Migration)	L	y
Waterfowl Group 1 (Wintering)	L	y
Waterfowl Group 2 (Breeding)	L	n
Waterfowl Group 2 (Migration)	L	y
Waterfowl Group 2 (Wintering)	L	n
Waterfowl Group 3 (Breeding)	M	n
Waterfowl Group 3 (Wintering)	L	n
Waterfowl Group 4 (Breeding)	L	n
Waterfowl Group 4 (Migration)	L	y
Waterfowl Group 4 (Wintering)	L	n
Waterfowl Group 5 (Breeding)	L	n
Waterfowl Group 5 (Migration)	H	y
Waterfowl Group 5 (Wintering)	L	n
Waterfowl Group 6 (Breeding)	L	n
Waterfowl Group 6 (Migration)	M	n
Waterfowl Group 6 (Wintering)	L	n
Waterfowl Group 7 (Breeding)	L	n
Waterfowl Group 7 (Migration)	L	y
Waterfowl Group 7 (Wintering)	L	n
Waterfowl Group 8 (Breeding)	L	n
Waterfowl Group 8 (Migration)	L	n
Waterfowl Group 8 (Wintering)	L	n
Waterfowl Group 9 (Breeding)	L	n
Waterfowl Group 9 (Migration)	M	n
Waterfowl Group 9 (Wintering)	L	n
Waterfowl Group 10 (Breeding)	L	n
Waterfowl Group 10 (Migration)	M	n
Waterfowl Group 10 (Wintering)	L	n
Waterfowl Group 11 (Breeding)	L	n
Waterfowl Group 11 (Migration)	L	n
Waterfowl Group 11 (Wintering)	L	n
Waterfowl Group 12 (Breeding)	L	y
Waterfowl Group 12 (Migration)	H	y
Waterfowl Group 12 (Wintering)	L	n
Waterfowl Group 13 (Breeding)	L	n
Waterfowl Group 13 (Migration)	L	n
Waterfowl Group 13 (Wintering)	L	n
Waterfowl Group 14 (Breeding)	L	n
Waterfowl Group 14 (Migration)	M	n
Waterfowl Group 14 (Wintering)	L	n
Belted Kingfisher	L	y
Spotted Sandpiper	L	y
Tree Swallow	M	y

****

Habitat Suitability Evaluation Results for "coldsprin"

****

Species/Group	Rating	Observed
Warmwater Fish Group	M	n
Coldwater Fish Group	L	n
Coldwater Riverine Fish Group	L	n
Northern Lake Fish Group	H	n
Yellow Perch	H	y
Bluegill	H	y
Smallmouth Bass	M	y
Redbreast Sunfish	H	y
Pumpkinseed	H	y
Waterfowl Group 1 (Breeding)	L	n
Waterfowl Group 1 (Migration)	H	y
Waterfowl Group 1 (Wintering)	L	n
Waterfowl Group 2 (Breeding)	L	n
Waterfowl Group 2 (Migration)	H	y
Waterfowl Group 2 (Wintering)	L	n
Waterfowl Group 3 (Breeding)	H	y
Waterfowl Group 3 (Migration)	H	y
Waterfowl Group 3 (Wintering)	L	n
Waterfowl Group 4 (Breeding)	L	n
Waterfowl Group 4 (Migration)	L	y
Waterfowl Group 4 (Wintering)	L	n
Waterfowl Group 5 (Breeding)	L	n
Waterfowl Group 5 (Migration)	H	y
Waterfowl Group 5 (Wintering)	L	n
Waterfowl Group 6 (Breeding)	L	n
Waterfowl Group 6 (Migration)	M	n
Waterfowl Group 6 (Wintering)	L	n
Waterfowl Group 7 (Breeding)	L	n
Waterfowl Group 7 (Migration)	L	y
Waterfowl Group 7 (Wintering)	L	n
Waterfowl Group 8 (Breeding)	L	n
Waterfowl Group 8 (Migration)	L	n
Waterfowl Group 8 (Wintering)	L	n
Waterfowl Group 9 (Breeding)	L	n
Waterfowl Group 9 (Migration)	M	n
Waterfowl Group 9 (Wintering)	L	n
Waterfowl Group 10 (Breeding)	L	n
Waterfowl Group 10 (Migration)	M	n
Waterfowl Group 11 (Breeding)	L	n
Waterfowl Group 11 (Migration)	L	n
Waterfowl Group 11 (Wintering)	L	n
Waterfowl Group 12 (Breeding)	L	n
Waterfowl Group 12 (Migration)	H	y
Waterfowl Group 12 (Wintering)	L	n
Waterfowl Group 13 (Breeding)	L	n
Waterfowl Group 13 (Migration)	L	n
Waterfowl Group 13 (Wintering)	L	n
Waterfowl Group 14 (Breeding)	L	n
Waterfowl Group 14 (Migration)	M	n
Waterfowl Group 14 (Wintering)	L	n
Green Heron	M	y

Great Blue Heron	M	y
Belted Kingfisher	L	y
Spotted Sandpiper	L	y
Tree Swallow	M	y

MACROINVERTEBRATE DATA ANALYSES

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APPENDIX P

Aquatic Macroinvertebrate Bioassessment
for Fort Devens, Massachusetts Pond Communities

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December, 1993

AQUATIC MACROINVERTEBRATE BIOASSESSMENT
FOR FORT DEVENS, MASSACHUSETTS POND COMMUNITIES

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APPENDIX P

AQUATIC MACROINVERTEBRATE BIOASSESSMENT FOR FORT DEVENS, MASSACHUSETTS POND COMMUNITIES

1.0 INTRODUCTION

Three ponds at Fort Devens, Massachusetts were sampled for benthic macroinvertebrates to assess pond similarities and provide baseline information for future studies. Two of the ponds, Plow Shop Pond and Cold Spring Brook Pond, are located adjacent to landfills, and the third pond, New Cranberry Pond, was used as a reference pond. The ponds were sampled on September 24 and 25, 1992. Three locations (stations), each including 25 m^2 areas of vegetated and non-vegetated substrate, were chosen in each pond. Two sampling points were randomly chosen within each of the 25 m^2 areas at each station. Two one-square meter sections of the areas with vegetated substrate were swept with a 600 micrometer mesh dip net to semi-quantitatively collect macroinvertebrates. The non-vegetated stations were sampled with a 9 x 9 inch Ekman dredge; two Ekmans were pushed into the substrate in each area to quantitatively collect macroinvertebrates. This sampling protocol provided two dip net and two Ekman dredge samples per station, with a total of 12 samples per pond. Each sample was preserved in 70% ethanol and sorted and classified as described in Nislow, 1993.

1.1 METRICS

The following metrics were calculated for each sample and pond: taxa richness, modified family biotic index (FBI), ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae (EPT/C), percent contribution of the dominant family, and the EPT index (Plafkin, et.al, 1989).

The metrics for the non-vegetated samples were treated separately from the vegetated samples for statistical analysis. Statistics on the metrics from the quantitative Ekman dredge sampler, although more consistent measures of area than the semi-quantitative dip net samples, tend to include more spatial heterogeneity because of clumped animal distributions and the small area they sample. The

Eckman samples encompass a 81 square inch area, which is only five percent of the area covered by the square meter sampled with dip nets. The smaller the area sampled, the smaller the number of organisms and taxa per sample. Because the Eckman samples are so much smaller than the vegetated dip net samples, the number of taxa (richness) and number of individuals within each taxa (abundance) are lower in the Eckman samples than the dip net samples. Therefore, the two samples were analyzed separately.

1.2 WATER QUALITY PARAMETERS

General water quality parameters collected from Plow Shop Pond and Cold Spring Brook Pond were compared to those collected from New Cranberry Pond to determine if any of these parameters could have contributed to or influenced the results of the macroinvertebrate community evaluation. In general, water quality parameters collected from stations at Plow Shop Pond and Cold Spring Brook Pond differed little from those at New Cranberry Pond. The pH at all ponds was fairly close to neutral and was within the chronic AWQC range for pH of 6.5 to 9 (USEPA 1986).

Conductivity measurements obtained from the ponds were markedly different, ranging from 179 to 195 microsiemens at Plow Shop Pond, 240 to 297 microsiemens at Cold Spring Brook Pond, and 43.6 to 49.6 microsiemens at new Cranberry Pond. This suggest a higher concentration of dissolved salts or total suspended solids in Plow Shop Pond and Cold Spring Brook Pond which may be reflective of differences in surface water quality. Dissolved oxygen (D.O.) at Plow Shop Pond ranged from 4.4 to 8.3 ppm and D.O. at New Cranberry Pond ranged from 5.8 to 5.9 ppm. The Plow Shop Pond temperature was roughly 3°C higher than the temperature at New Cranberry Pond (17° versus 14°C).

General water quality parameters within each pond were evaluated to identify potential differences or trends associated with proximity to the landfill sources. The parameters measured at the three stations within Plow Shop Pond did not vary greatly, with the exception of D.O., which was lower at Station 1 (4.4 ppm) than at Stations 2 and 3 (7.3 ppm and 8.3 ppm, respectively). Station 1 is the furthest station from Shepley's Hill Landfill, and therefore this difference, if significant, does not appear to be attributable to the landfill. The water quality parameters measured within Cold Spring Brook Pond varied little.

Eutrophic New England ponds exhibit a wide variety of pH, temperature, and D.O. conditions across spatial and temporal gradients, and resident organisms must be able to tolerate these diverse conditions. The general water quality parameters do not appear to be influencing factors in the differences observed between the macroinvertebrate communities at the three ponds or at the different stations within a pond.

2.0 VEGETATED SUBSTRATE ANALYSES

Table P-1a presents the metrics listed above for the macroinvertebrates in the 18 semi-quantitative dip net sampled vegetated areas.

Table P-1a. Metrics for dip net (vegetated area) samples

POND	Plow Shop			Cold Spring			Cranberry		
STATION	1	2	3	1	2	3	1	2	3
SAMPLE #	1	3	5	13	15	17	25	27	29
Taxa Richness	18	16	17	25	20	23	22	13	17
Biotic Index	6.75	6.80	7.58	7.00	6.74	6.56	6.22	5.93	6.1
EPT/Chironomidae	2.75	0.20	0.44	1.35	0.28	0.68	0.39	0.58	2.40
% Dominant Taxon	50.6	40.6	36.6	37.8	28.8	24.7	20.1	69.2	34.6
EPT Index	4	2	2	5	3	2	2	1	4

POND	Plow Shop			Cold Spring			Cranberry		
STATION	1	2	3	1	2	3	1	2	3
SAMPLE #	2	4	6	14	16	18	26	28	30
Taxa Richness	13	16	18	25	20	18	24	19	24
Biotic Index	7.19	6.77	7.50	6.84	6.40	6.48	5.74	6.61	6.14
EPT/Chironomidae	2.67	0.73	1.00	2.09	0.07	0.75	0.35	1.17	0.86
% Dominant Taxon	50.4	45.6	45.1	28.4	22.2	34.8	28.7	21.2	28.8
EPT Index	3	3	3	3	1	3	3	3	6

Statistical comparisons among the ponds using the five metrics from dip net samples were done with the Kruskal-Wallis test. When significant differences were seen between ponds, ANOVA with Tukey's Studentized Range (which controls type I experiment-wise error rates at an alpha level of 0.05 in these comparisons) were used to assess which ponds were significantly different. The means for the dip net indices in each pond are shown in Table P-2a.

Table P-2a. Mean values for metrics from dip net (vegetated area) samples with p-values for Kruskal-Wallis Test

POND	Plow Shop	Cold Spring	Cranberry	p-value
Taxa Richness	16.33	21.83	19.83	0.023 *
Biotic Index (FBI)	7.10	6.67	6.12	0.003 **
EPT/Chironomidae	1.30	0.87	0.96	0.778
% Dominant Taxon	44.83	29.49	33.79	0.025 *
EPT Index	2.83	2.83	3.16	0.939

* $p<0.05$, ** $p<0.01$

2.1 Taxa Richness

Table P-2a indicates the level of impact on the macroinvertebrates in the vegetated substrates within Plow Shop Pond Plow Shop Pond has a significantly lower taxa richness (mean=16.3, p=0.023) than New Cranberry Pond (mean=19.8) or Cold Spring Brook Pond (mean=21.8). The reduced taxa richness of Plow Shop Pond may be indicative of pond contamination or landfill impacts. The Tukey multiple comparison (not shown here) indicates taxa richness is not significantly different between New Cranberry Pond and Cold Spring Brook Pond, the latter actually having a higher index.

2.2 Family Biotic Index

Because the FBI was created for lotic habitats, it had to be adapted for lentic habitats for purposes of this study. The biotic index used for lotic habitats assigns

pollution tolerance values to different taxa; taxa with low pollution tolerances are assigned a zero, and taxa with very high tolerances are assigned a ten. The biotic index created for lotic habitats also assigned a zero tolerance to taxa with unknown pollution tolerances. Lotic habitats typically have higher oxygen levels than lentic habitats; therefore, taxa that exist in lotic systems with low oxygen levels are pollution tolerant, while the same taxa in a lentic system may not be indicative of pollution. To account for this difference between lotic and lentic habitats, a median value of 5.5 was assigned to taxa with unknown tolerances for these lentic data. This modification is a more realistic representation of a lentic taxas' tolerance status when the actual pollution tolerance is unknown.

A comparison of FBIs shows that New Cranberry Pond has a significantly lower FBI (a lower FBI indicates the presence of more pollution intolerant taxa) (mean=6.12, p=0.003). Tukey's multiple comparison test also shows a statistically non-significant difference between the higher biotic indices of Plow Shop Pond (mean=7.10) and Cold Spring Brook Pond (mean=6.67). The higher biotic indices may be indicative of contamination or landfill impacts, with the suggestion that Cold Spring Brook Pond may be less impacted than Plow Shop Pond.

2.3 EPT/C

The ratio of Ephemeroptera, Plecoptera, and Trichoptera to the number of Chironomidae (EPT/C) is very similar among the three ponds. However, the number of organisms in the EPT relative to the number in the dipteran family Chironomidae may not be as sensitive an indicator of water contamination for lentic habitats as it is in lotic water bodies.

2.4 Dominant Taxa

Polluted ponds tend to have larger numbers of taxa most tolerant to pollution relative to the other taxa. The significantly higher percentage of the dominant taxon relative to other taxa at Plow Shop Pond (mean=44.8%) may be indicative of pond contamination. New Cranberry Pond (mean=33.8%) and Cold Spring Brook Pond (mean=29.5%) are not significantly different in the percentage of the dominant taxon using the Tukey multiple comparison. The dominant taxon at all stations and all samples at Plow Shop Pond was the scavenger crustacean *Hyallela azteca*

(Table P-3a). Out of the six samples taken from vegetated substrates at each pond, New Cranberry Pond had *Hyallela azteca* as the dominant species in one sample, and Cold Spring Brook Pond had this species as the dominant in two samples. However, cladocerans and turbellarians were dominant in other samples at New Cranberry Pond, and cladocerans were dominant in samples at Cold Spring Brook Pond. There are low numbers of Ephemeropteran, Plecopteran, and Trichopteran taxa in the samples from vegetated substrates in these ponds, and they appear uniformly distributed across ponds.

Table P-3a. Dominant taxon from each dip net (vegetated area) sample

POND	STATION	SAMPLE	TAXON	PERCENT OF SAMPLE
Plow Shop	1	1	*Hyalella azteca*	51
Plow Shop	1	2	*Hyalella azteca*	50
Plow Shop	2	3	*Hyalella sp.*	41
Plow Shop	2	4	*Hyalella azteca*	46
Plow Shop	3	5	*Hyalella azteca*	37
Plow Shop	3	6	*Hyalella azteca*	45
Cold Spring	1	13	*Hyalella azteca*	38
Cold Spring	1	14	*Hyalella azteca*	28
Cold Spring	2	15	Chydoridae *	28
Cold Spring	2	16	Chydoridae *	22

Table P-3a. Dominant taxon from each dip net (vegetated area) sample

POND	STATION	SAMPLE	TAXON	PERCENT OF SAMPLE
Cold Spring	3	17	*Eurycercus sp.* *	25
Cold Spring	3	18	*Eurycercus sp.* *	35
Cranberry	1	25	*Hyalella azteca*	20
Cranberry	1	26	Aceola	29
Cranberry	2	27	Cladocera	69
Cranberry	2	28	Chydoridae *	21
Cranberry	3	29	Cladocera	35
Cranberry	3	30	Cladocera	29

* Cladocera

3.0 NON-VEGETATED SUBSTRATE ANALYSIS

Table P-1b presents metrics for the macroinvertebrates found in the 18 quantitative Ekman dredge samples from non-vegetated areas.

Table P-1b. Metrics for Ekman dredge (non-vegetated area) samples

POND	Plow Shop			Cold Spring			Cranberry		
STATION	1	2	3	1	2	3	1	2	3
SAMPLE #	7	9	11	19	21	23	31	33	35
Taxa Richness	17	11	5	10	5	12	12	20	15
Biotic Index	7.00	7.41	6.37	6.89	7.75	7.01	7.23	7.32	7.79
EPT/Chironomidae	0.17	0.60	0.05	27.5	0.01	0.03	0.27	1.18	0.14
% Dominant Taxon	38.9	20.7	37.5	40.7	33.3	54.8	26.4	26.1	34.5
EPT Index	2	1	0	2	0	1	3	5	3

POND	Plow Shop			Cold Spring			Cranberry		
STATION	1	2	3	1	2	3	1	2	3
SAMPLE #	8	10	12	20	22	24	32	34	36
Taxa Richness	20	16	5	15	8	11	19	23	17
Biotic Index	7.21	6.92	6.10	7.36	6.60	6.78	7.48	7.06	7.16
EPT/Chironomidae	2.78	0.30	0.05	1.21	0.05	0.03	0.61	0.29	0.82
% Dominant Taxon	34.6	15.5	40.0	38.0	66.1	42.5	53.7	21.4	15.4
EPT Index	4	2	0	1	2	1	3	4	4

Statistical comparisons of the three ponds using the five metrics from the quantitative Ekman dredge samples on non-vegetated sites were made using Kruskal-Wallis nonparametric ANOVAs. Multiple comparisons on metrics showing significant differences between ponds were made with Tukey's standardized range test using a type I error rate of 5%. The mean values and comparative statistics for the five metrics at each of the three ponds are presented in Table P-2b.

Table P-2b. Mean values for metrics from Eckman dredge (non- vegetated) samples with p-values for the Kruskal-Wallis Test

POND	Plow Shop	Cold Spring	Cranberry	p-value
Taxa Richness	12.33	10.67	17.67	0.043 *
Biotic Index	6.84	7.06	7.34	0.128
EPT/Chironomidae	0.66	4.81	0.44	0.443
% Dominant Taxon	31.22	45.92	29.63	0.057
EPT Index	2.25	1.40	3.67	0.012 *

* $p<0.05$, ** $p<0.01$

3.1 Taxa Richness

The statistical analysis of the metrics from the non-vegetated macrobenthos suggest that Plow Shop and Cold Spring Brook Ponds may be impacted and that New Cranberry Pond is a suitable reference pond. The taxa richness is highest at the reference site, New Cranberry Pond (mean=17.7). New Cranberry Pond's taxa richness is significantly higher than that of Cold Spring Brook Pond (mean=10.7, p=0.043). However, multiple comparisons reveal that New Cranberry Pond does not have a significantly higher taxa richness than Plow Shop Pond (mean=12.3), and that Plow Shop Pond's taxa richness is not significantly different from Cold Spring Brook Pond.

3.2 Family Biotic Index

The modified family biotic index is not significantly different among the three ponds. This result is different than the results in the dip net samples, where the reference pond had the lowest biotic index. This is likely a result of the reduced number of individuals and taxa per sample from the Eckman dredge not providing sufficient information to discriminate between pond indices by averaging across sample biotic indices.

3.3 EPT/C

The ratio of Ephemeroptera, Plecoptera and Trichoptera to Chironomidae (EPT/C) is not significantly different in the non-vegetated areas among ponds. This is similar to the situation found in the vegetated areas, supporting the idea that the EPT/Chironomidae index may not be a sensitive water contamination indicator for ponds or other lentic habitats. The high mean EPT/Chironomidae ratio at Cold Spring Brook Pond (mean=4.8) is caused by a single sample with 55 caenid (ephemeroptera) mayflies and only 2 chironomids producing a ratio of 27.5. The next highest sample ratio was 2.7, and the majority of ratios were less than one. This variation is due to the small area sampled and the spatial clumping of organisms on the substrate.

3.4 EPT INDEX

New Cranberry Pond has a significantly higher number of taxa in the EPT orders (mean=3.67; p=0.012) than Cold Spring Brook Pond (mean=1.40). The mean number of EPT taxa at Plow Shop Pond (mean=2.25) is not significantly different than the other two ponds using Tukey's multiple comparison. The EPT taxa numbers are again suggestive of impacts at Cold Spring Brook Pond and Plow Shop Pond.

3.5 DOMINANT TAXA

Cold Spring Brook Pond had the highest percentage of individuals in a dominant taxon (mean=45.9%), indicating possible landfill impacts on the macrobenthos population. There is not a statistically significant difference between the mean percentages at Plow Shop Pond (mean=31.2%) or New Cranberry Pond (mean = 29.6%), but the p-value (p=0.057) is close to significance. This indicates that the difference between the high and low percentages is probably biologically significant, the reference pond having a better balance of number of organisms (abundance) per number of taxa. This also suggests that Cold Spring Brook Pond may be impacted relative to New Cranberry Pond.

Table P-3b presents the dominant taxa from the non-vegetated area samples.

Table P-3b. Dominant taxon from each Eckman dredge (non- vegetated area) sample

POND	STATION	SAMPLE	TAXON	PERCENT OF SAMPLE
Plow Shop	1	7	*Hyalella azteca*	37
Plow Shop	1	8	*Hyalella azteca*	45
Plow Shop	2	9	Oligochaeta	11
Plow Shop	2	10	*Eurycercus sp.* *	9
Plow Shop	3	11	*Lymnaea sp.*	3
Plow Shop	3	12	*Chaoborus punctipennis*	4
Cold Spring	1	19	*Caenis sp.*	46
Cold Spring	1	20	*Caenis sp.*	35
Cold Spring	2	21	Oligochaeta	4
Cold Spring	2	22	Chironomidae	74
Cold Spring	3	23	Oligochaeta	51
Cold Spring	3	24	Oligochaeta	37
Cranberry	1	31	Oligochaeta	9

Table P-3b. Dominant taxon from each Eckman dredge (non- vegetated area) sample

POND	STATION	SAMPLE	TAXON	PERCENT OF SAMPLE
Cranberry	1	32	*Hyallela azteca*	51
Cranberry	2	33	Chironomidae	34
Cranberry	2	34	Chironomidae	30
Cranberry	3	35	Tubificidae	46
Cranberry	3	36	Chironomidae	23

* Cladocera

The dominant taxa are different in the non-vegetated sites than in the vegetated sites, although *Hyalella azteca* dominates in two samples from Plow Shop Pond and one sample from New Cranberry Pond. The cladocerans that were prevalent in the vegetated areas are replaced by oligochaete and tubificid worms or chironomids in the non-vegetated areas. There is greater variation in the percentages of the dominant species because of the smaller sample area and clumped distribution of organisms.

It appears that the invertebrate taxa in the non-vegetated areas may not be as sensitive as indicators of pollution compared to those on vegetated sites, at least with the current level of taxonomic identification. The dominance of oligochaetes (worms) and chironomids (midges) may be indicative of water contamination in a lotic water system, but the relationship between contamination and worms and midges is not as clear in pond habitats.

4.0 RAPID BIOASSESSMENT PROTOCOL METRIC COMPARISON

Evaluation of the ratio of each metric from the reference pond and the potentially impacted ponds was conducted per the guidance of the EPA Rapid Bioassessment Protocol (RBP) (Plafkin, et. al., 1989). Each ratio was scored for percent similarity between ponds; scores were then summed across metrics and the total score was compared with the total metric score for the reference station. The scores for the percent similarity were taken from the Rapid Bioassessment Protocol III (RBP-III) for benthic macroinvertebrates. The RBP-III method is appropriate for taxonomic identification to the lowest possible taxonomic level, as was done for these analyses. Table P-4 presents comparisons of five metrics used for statistical analysis, together with the ratio scores. The values calculated for the pond metrics are not means of samples, but incorporate the information from all samples in a pond, combining data from vegetated and non-vegetated sites to provide an overall pond index to be used in the pond comparison ratios (Table P-5).

Table P-4. Percent Comparability between habitat indices for Plow Shop Pond versus New Cranberry Pond (PSP-NCP), Cold Spring Brook Pond versus New Cranberry Pond (CSBP-NCP) and Rapid Bioassessment Protocol - III Scores

POND COMPARISON	PSP-NCP		CSBP-NCP		Reference
MEASUREMENT	ratio	score	ratio	score	score
Taxa Richness	88.8	6	100.0	6	6
Biotic Index (FBI)	93.4	6	96.9	6	6
EPT/Chironomidae	71.9	4	70.2	4	6
% Dominant Taxon	34.5	2	16.8	6	6
EPT Index	80.0	4	80.0	4	6
TOTAL		22		26	30

Comparing the score of Plow Shop Pond (22) with a reference score of 30 gives a bioassessment ratio of 73%, or slightly impaired. The RBP-III interprets this as a community structure that is less than expected. The species richness is reduced by the loss of some pollution intolerant forms, and the numbers of tolerant forms relative to other taxa is increased. The comparison of the score for Cold Spring Brook Pond (26) with a reference score of 30 gives a bioassessment ratio of 87%, or non-impaired. The RBP-III interprets this as the best situation to be expected within

an ecoregion. The Cold Spring Brook Pond community composition and structure is considered to be by not impacted RBP-III.

Table P-5. Whole pond metrics used for percent comparability

POND	Plow Shop	Cold Spring	Cranberry
Taxa Richness	62	70	70
Biotic Index (FBI)	7.08	6.83	6.61
EPT/Chironomidae	0.75	0.77	0.54
% Dominant Taxon	34.5	16.8	16.6
EPT Index	8	8	10
Dominant Taxon	*Hyalella azteca*	*Hyalella azteca*	Cladocera

The results of the statistical analyses and RBP bioassessment method produce similar conclusions. Plow Shop Pond's benthic macroinvertebrate community may be impacted relative to New Cranberry Pond. It is not as clear that the macrobenthos at Cold Spring Brook Pond have been impacted. Table P-5 shows that the scavenger species *Hyalella azteca* is the dominant taxon in both Plow Shop and Cold Spring Brook Ponds, whereas cladocerans dominate in New Cranberry Pond. The common dominant taxon could indicate that similar ecological pressures, such as contamination, are affecting the macroinvertebrate communities of these two ponds. It is also possible that the reference pond, although adequate for this study, is not absolutely the "best situation to be expected within an ecoregion" (the RBP standard).

The RBP-III scores may have come out differently with the addition of three additional metrics typically used in lotic systems: the two trophic indices and the

community loss index. The trophic structure of ponds is so different from running water systems that the trophic indices were not applicable in this analysis and is dealt with separately. The similarity of the ponds was also very low, and therefore the community loss index did not seem to apply in this situation.

5.0 TAXONOMIC SIMILARITY OF PONDS AND STATIONS WITHIN PONDS

Table P-6 presents Jaccard Coefficients of Community Similarity (JC) between ponds and stations within ponds. It is clear that the three ponds are fairly dissimilar in community composition; this is consistent with preceding results. Specifically, Plow Shop Pond and New Cranberry Pond are least similar of the three ponds (JC=0.347), Plow Shop and Cold Spring Brook Ponds are most similar (JC=0.389), and New Cranberry and Cold Spring Brook Ponds are more similar to one another (JC=0.386) than Plow Shop Pond is to the reference pond. It appears that the macroinvertebrate communities of the two ponds adjacent to landfills are more similar to one another than they are to the reference pond, and Cold Spring Brook Pond's macroinvertebrate community seems less disturbed than Plow Shop Pond's.

Table P-6. Jaccard Coefficients of Community Similarity among ponds and stations within ponds

Pond Comparison	Plow-Cran	Cold-Cran	Plow-Cold
	0.347	0.386	0.389
Station Comparison	1-2	1-3	2-3
Plow Shop Pond	0.278	0.340	0.381
Cold Spring Brook	0.288	0.339	0.340
Cranberry Pond	0.466	0.328	0.456

The comparison of Jaccard Coefficients among stations within a pond shows that the similarity among stations within a pond is not too different from the similarity among ponds. The similarity among the stations at the reference pond, New Cranberry Pond, appears to be greater than the similarity among stations in the other ponds. The differences among stations in Plow Shop and Cold Spring Brook Ponds could be attributable to the location of the stations relative to the location of the adjacent landfills. Stations 2 and 3 are adjacent to the landfill at Plow Shop Pond, while station 1 is on the other side of the pond. The similarity between station 2 and 3 is the greatest (JC=0.381) indicating more comparable macrobenthos communities than either station has with station 1. This may be attributable to the effect the landfill has on the macrobenthos communities at the two stations adjacent to them.

The landfill at Cold Spring Brook Pond is closest to station 2, then to station 3, and farthest from station 1. The stations are all on the same side of the pond as the landfill. Station 1, the farthest from the landfill, is most dissimilar to station 2, the closest to the landfill (JC=0.288). Stations 2 and 3 are most similar to one another (JC=0.34). The similarity between station 1, farthest from the landfill, and station 2 is almost the same (JC=0.339) as that between stations 2 and 3 (JC=0.340).

The differences between stations in macrobenthos community structure at Cold Spring Brook Pond seem less than those at Plow Shop Pond. This may indicate that the landfill adjacent to Plow Shop Pond may have more of an impact on the pond's macroinvertebrate community than the other landfill has on Cold Spring Brook Pond's macroinvertebrate community.

6.0 STATISTICAL ANALYSIS OF MACROINVERTEBRATE ABUNDANCE

6.1 DATA TRANSFORMATION

Macroinvertebrate abundance (i.e., the number of individuals within various taxa) was analyzed by combining data from vegetated and non-vegetated areas in each pond. This provided four samples per station and 12 samples per pond for analyses between stations within ponds, and among ponds. The data were transformed so that the unit area used to count organisms for both the square meter of the vegetated areas and the approximately 5% of a square meter of the non-vegetated areas were equivalent. This was done by multiplying the number of organisms collected per

square meter on vegetated areas by the proportion of the square meter encompassed by the 81 square inches of the Ekman dredge sampler on non-vegetated areas. The data for these analyses were either the sum of the number of macroinvertebrates per sample, or the sum of the number of macroinvertebrates in each order for each sample.

6.2 Comparison Among Ponds

The sums of macroinvertebrates per sample were used to compare macroinvertebrate abundance among ponds and between stations within a pond. Comparisons among ponds used 12 samples per pond, and were compared using a non-parametric ANOVA (Kruskal-Wallis Test). Table P-7 shows the mean number of macroinvertebrates in the three ponds where the p-value for the Kruskal-Wallis tests for differences in macroinvertebrate abundance among ponds.

Table P-7. Mean number of macroinvertebrates per sample with p-value for Kruskal-Wallis Test.

POND	Plow Shop	Cold Spring	Cranberry	p-value
mean	79.8	189.7	184.7	0.212

The abundance of macroinvertebrates is not significantly different among the three ponds. The mean of approximately 80 macroinvertebrates per sample at Plow Shop Pond indicates that pond contamination may be reducing macroinvertebrate abundance. However, the large variation in the mean number among samples (which is explained by variation between stations in the within pond analysis) causes the differences to be statistically non-significant despite a mean difference of over 100 organisms per sample between Plow Shop and the other two ponds.

6.3 Comparison Among Stations Within a Pond

Comparisons among the three stations at each pond used the sum of macroinvertebrates per sample, so that there were four samples (sums) from each station for statistical evaluation. Table P-8 presents the mean macroinvertebrate abundance at each station in the three ponds (where the p-value for the Kruskal-Wallis tests for differences in macroinvertebrate abundance among stations within a pond).

Table P-8. Mean number of macroinvertebrate at each station in each pond with p-values for the Kruskal-Wallis Test

POND	MEAN FOR STATION 1	MEAN FOR STATION 2	MEAN FOR STATION 3	p-value
Plow Shop	169.5	47.7	22.2	0.037 *
Cold Spring	354.5	113.0	101.5	0.059
Cranberry	71.7	185.2	295.0	0.584

* $p<0.05$

The analysis of the variation in macroinvertebrate abundance within ponds may be indicative of landfill impacts on the invertebrate populations. The mean number or macroinvertebrates at stations 2 (mean=47.7) and 3 (mean=22.2) (abutting Shepley's Hill Landfill) are significantly lower than at station 1 (mean=169.5, p=0.037) on the other side of the pond. This suggests that greater reduction in the macroinvertebrate abundance is related to the proximity of the station in the pond to the landfill. The situation is similar at Cold Spring Brook Pond, with stations 2 and 3 being closer to the landfill and having approximately the same reduction in macroinvertebrate abundance. There is not a statistically significant difference in the mean number of macroinvertebrates per sample among stations 1 (mean=354.5) and stations 2 (mean=113) and 3 (mean=101.5, p=0.059), although the p-value is close enough to 0.05 to indicate a biologically meaningful reduction in taxa in the two stations closest to the landfill contaminants.

There is a great deal of variation in the abundance of macroinvertebrates in each sample from New Cranberry Pond, which is the reason for the large spread in means at the stations in the reference pond. The difference in macroinvertebrate abundance among the stations at New Cranberry Pond is not even close to significant ($p=0.584$), indicating a fairly even abundance of macroinvertebrates across the pond despite the high variation in numbers among samples. The within pond analysis of macroinvertebrate abundance relates well to the taxa similarity indices (i.e., Jaccard Coefficients) comparing stations within ponds. Stations nearest to landfills, regardless of the pond, showed similar reductions in macroinvertebrate abundance. This reduction in macroinvertebrate abundance corresponds to the Jaccard Coefficients, which showed that stations nearest the landfills were most similar to each other. Stations farthest away from the landfills had higher numbers of taxa and a higher abundance of macroinvertebrates. In addition, the Jaccard Coefficients at these stations showed they were most dissimilar to the stations nearest the landfills.

6.4 Statistical Analysis of Abundance of Orders Among Ponds

The data analysis indicating differences in the abundance of the extant orders among ponds were summed by sample and order. The resulting data set had the sum of all individuals in an order for a given sample. If the order was not represented in the sample, then the information was considered missing. The comparisons of ponds analyzing each order separately allows for tests of difference in abundance among ponds, and provides baseline information on the mean number of organisms per sample in each order for the three ponds. Table P-9 provides the mean number of macroinvertebrates per sample for each pond, with a p-value for the Kruskal-Wallis testing for differences in abundance of the orders among ponds. Note that the number of samples (N) for each comparison across ponds is provided in Table P-9. This is because some samples lacked representatives of a given order, which reduces the sample size, and hence the power of the comparison among ponds. Some ponds had no representatives of an order in the samples that were taken, so several of the among pond comparisons in Table P-9 include only two ponds.

Finally, some ponds show a mean number of zero macroinvertebrates; this is a result of rounding a transformed value from a square meter of vegetated area. This indicates that a single macroinvertebrate in the given order was collected in a single sample from the pond. The samples with zero macroinvertebrates also produce slight underestimates of the mean number of macroinvertebrates per sample in an order.

Table P-9. Mean number of macroinvertebrates in a pond by order with p-values for the Kruskal-Wallis Test

POND	Plow Shop		Cold Spring		Cranberry		
ORDER	N	Mean	N	Mean	N	Mean	p-value
Acariformes	-	-	4	5.2	1	0.0	0.276
Acoela	7	8.0	-	-	4	7.7	0.703
Amphipoda	10	33.2	8	44.1	12	31.7	0.871
Basommatophora	12	7.5	5	2.0	9	16.0	0.330
Cladocera	10	3.1	8	12.7	7	19.0	0.008**
Coleoptera	-	-	3	3.0	3	2.3	0.637
Collembola	2	0.5	1	0.0	2	1.5	0.271
Cyclopoida	-	-	6	4.7	4	1.7	0.154
Diptera	12	13.6	12	58.3	12	56.4	0.035*
Ephemeroptera	10	9.1	11	48.4	12	13.7	0.185
Haplotaxida	1	0.0	1	7.0	9	31.2	0.254
Hemiptera	5	1.0	7	3.4	3	1.3	0.340
Hydracarina	1	1.0	2	3.5	-	-	0.479
Isopoda	1	5.0	-	-	3	2.3	0.157
Lepidoptera	6	0.8	3	1.0	1	3.0	0.201
Megaloptera	-	-	2	14.0	1	0.0	0.221
Odonata	10	7.1	10	9.5	10	8.5	0.873
Oligochaeta	5	4.8	10	31.4	5	17.4	0.472
Ostracoda	4	1.2	3	3.0	2	1.5	0.680
Pelecypoda	2	19.0	2	5.5	5	15.2	0.181
Rhynchobdellid	3	2.7	1	0.0	1	3.0	0.606
Testacea	1	0.0	-	-	6	5.5	0.295
Trichoptera	8	2.1	6	2.0	10	8.1	0.223

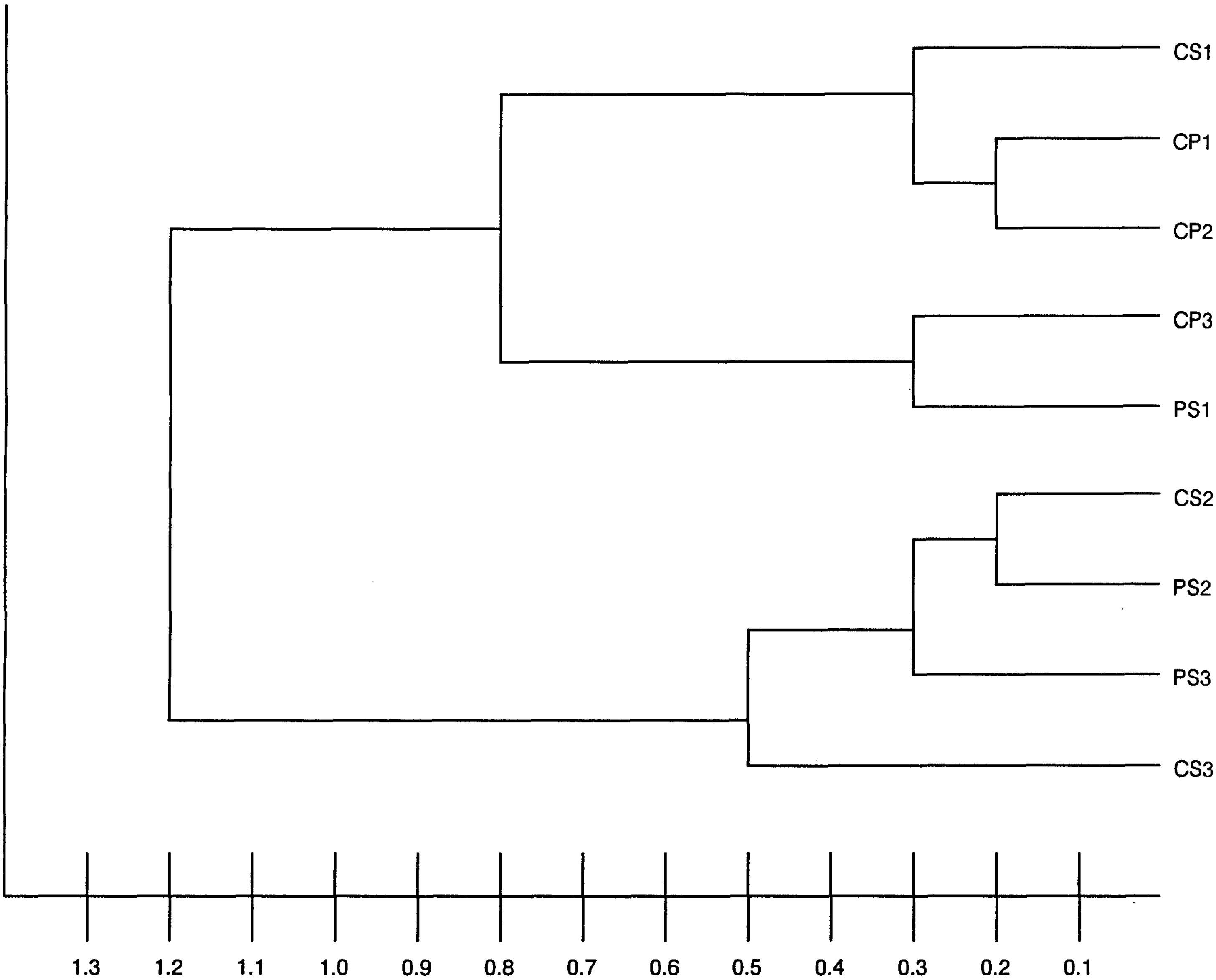
* $p<0.05$, ** $p<0.01$

There are very few statistically significant differences among ponds in the abundance of macroinvertebrates grouped by order. The cladocera are significantly less abundant in Plow Shop Pond (mean=3.1, p=0.008) than in Cold Spring Brook (mean=12.7) and New Cranberry (mean=19) Ponds. This is consistent with the higher level of contamination in Plow Shop Pond. The abundance of diptera is also significantly lower at Plow Shop Pond (mean=13.6, p=0.035) than in Cold Spring Brook (mean=58.3) and New Cranberry (mean=56.4) Ponds. The fact that there are four orders with no representatives collected in Plow Shop Pond, three orders with no representatives collected in Cold Spring Brook Pond, and only one order with no representatives collected from New Cranberry Pond may be as good an indicator of potential landfill impacts on ponds as the ordinal abundance comparisons.

7.0 CLUSTER ANALYSIS OF TAXONOMIC METRICS

Multivariate analysis of the 5 metrics (taxa richness, modified family biotic index, ratio of EPT/Chironomidae, percent contribution of the dominant taxon, and EPT Index) is another way of examining the relationships of the stations and ponds. The unweighted pair group method using arithmetic averages was used to evaluate the average linkage among stations. Estimated distances between stations are squared. The distance between clusters is measured by normalized root mean squares of the difference between two clusters. Figure P-1 shows the cluster relationships of the 9 stations and three ponds.

Figure P-1. Clustering relationships of the 9 stations based on the 5 taxonomic metrics.



The stations at Cold Spring Brook Pond are labeled CS1, CS2, and CS3; the stations at New Cranberry Pond are labeled CP1, CP2, and CP3; and the stations at Plow Shop Pond are labeled PS1, PS2, and PS3. The cluster analysis breaks the stations into two main clusters. One cluster contains all of the stations in the potentially

impacted ponds that are closest to the landfill (CS2, PS2, PS3, CS3); the other cluster includes all the stations at Cranberry Pond plus the stations that are the farthest from the landfills in Plow Shop and Cold Spring Brook Ponds (CS1, CP1, CP2, CP3, PS1). It is interesting to note that in the potentially impacted stations cluster, the stations that are most similar (CS2, PS2) are also the sites closest to the landfill at each pond. The closest stations in the non-impacted sites cluster (CP1, CP2) are both in New Cranberry Pond, and also had the highest Jaccard Coefficient for Community Similarity (not one of the metrics used in the cluster analysis) between any two stations within a pond (see Table P-6).

The conclusions to be drawn from the results of the cluster analysis are in accordance with the results of the previous analyses. The closer a station is to a landfill, the greater the apparent impact on the macroinvertebrate community. The landfill stations clustered closer together, indicating that the landfills may have had similar effects in reducing the number of taxa and abundance of macroinvertebrates, increasing the proportions of dominant taxa, increasing the number of contamination-tolerant taxa, and selectively eliminating certain taxonomic groups. Conversely, the New Cranberry Pond stations and the Plow Shop and Cold Spring Brook Pond stations furthest from the landfills clustered most closely together, suggesting similarly well balanced macroinvertebrate communities. The clustering indicates that New Cranberry Pond may have more of an optimal macroinvertebrate community structure, and is an adequate choice as a reference pond. The clustering also indicates that Plow Shop Pond may have a more disturbed macroinvertebrate community than does Cold Spring Brook Pond. This is seen by the closer clustering of the optimal stations at New Cranberry Pond with the station furthest from the landfill at Cold Spring Brook Pond (CP1, CP2, CS1), and the closer clustering of the station closest to the landfill at Cold Spring Brook Pond with both landfill stations at Plow Shop Pond (CS2, PS2, PS3).

8.0 RELATIONSHIP OF SEDIMENT CHEMISTRY AND MACROINVERTEBRATES

8.1 MACROINVERTEBRATE ABUNDANCE AND SEDIMENT CHEMISTRY

The relationship between macroinvertebrate abundance and sediment chemistry was analyzed with simple linear and multiple regression models. The differences between ponds in sediment chemistry and macroinvertebrate abundance (measured in organisms per square meter) are assessed qualitatively with graphs and tables relating

COPC levels to numbers of organisms. Analyses were run separately for substrate and vegetation macroinvertebrates, as well as combining data from the two strata. The separation of analyses according to bottom-dwelling and vegetation-inhabiting invertebrates was done because it is possible that sediment chemistry may have different effects on organisms living on the bottom versus higher in the water column. Inorganic and organic compounds were analyzed separately because the impact of inorganic compounds should be more site-specific within these study ponds, whereas the organic chemicals (DDD, DDE, DDT) were fairly uniformly distributed at low concentrations within and among ponds.

8.1.1 Organic Pesticides

There is no indication of a relationship between levels of organic pesticides and macroinvertebrate abundance using these data. Simple linear regressions of macroinvertebrate abundance and levels of DDT, DDE, and DDD from 36 macroinvertebrate samples produce the highest R-square values for DDT, with less than 1.9 percent in combined samples, less than 2.2 percent in vegetation samples, and less than 3.1 percent in substrate samples. Macroinvertebrate abundance declined with increasing levels of DDT as indicated by the negative slope in, Tables 10, 11, and 12, whereas abundance increased with increasing levels of DDD and DDE (positive slopes in Tables P-10, P-11, P-12). The best fitting multiple regression model based on a combination of R-square and Mallow's C(p) statistics was seen in the substrate sample with DDD, DDE, and DDT in the model and an adjusted R-square of 29%. The results of the multiple regression model on organic chemicals are incongruous with the mixture of positive and negative slopes. Although certain chlorinated hydrocarbons may have a significant impact on invertebrate abundance, these statistical analyses demonstrate that the concentrations in the ponds studied at Fort Devens appear to be at levels beneath the impact threshold and are not a significant factor in the macroinvertebrate abundance differences.

8.1.2 Inorganic Chemicals

The result of simple linear regression analyses of inorganic chemicals found at detectable levels in the study ponds for substrate (Table P-10), vegetation (Table P-11), and combined (Table P-12) macroinvertebrate samples indicate that no single inorganic compound is strongly related to macroinvertebrate abundance. The slopes are negative for the majority of compounds, indicating that increasing levels of most chemicals may result in a decreased macroinvertebrate abundance. The macroinvertebrate abundance relationship with key inorganic chemicals, as measured by highest R-squares (marked with an asterisk in the tables), is slightly stronger in

substrate (Table 10) than vegetation macroinvertebrates (Table 11). The key COPCs are also different in substrate (Co, Fe, Ni, As, Mn) than vegetation (Na, Sb, As, Ba, Ni) macroinvertebrates, although there is some overlap. The differences between the key COPCs in the substrate and vegetation macroinvertebrates contribute to the even weaker relationship between the combined site macroinvertebrate abundances and inorganic chemical levels. The differences also affect the key COPC components (Co, As, Fe, Ni, Mn), although the key chemicals for the combined sites are probably the most likely to affect macroinvertebrate abundance in these ponds.

Table P-10. Nonvegetated Sites - Ekman Dredge Samples Regression Models for Macroinvertebrate Numbers

N = 18

Chemical	Adjusted R-square	R-square	Parameter Estimates Intercept	Parameter Estimates Slope
Al	-.06177740	0.00068010	239.2	-0.00154
*As	0.15470735	0.20443045	309.3	-0.7606
Ba	-.06240512	0.00008930	224.6	0.0833
Be	0.09248778	0.14587085	281.4	-639.7
Ca	-.03819133	0.02287875	244.2	-0.00240
Cd	0.09248778	0.14587085	281.4	-456.9
*Co	0.21347395	0.25974019	296.6	-6.3696
Cr	-.06249024	0.00000919	227.8	0.000619
Cu	-.06238910	0.00010438	226.6	0.1161
*Fe	0.18368410	0.23170268	325.2	-0.00665
Hg	-.05587962	0.00623095	221.5	1.6157
K	0.09446933	0.14773584	122.5	0.3156
Mg	-.03066263	0.02996458	283.8	-0.0378
*Mn	0.15307093	0.20289029	304.6	-0.1240
Na	0.00001022	0.05883314	307.6	-0.1384
*Ni	0.15634504	0.20597181	333.3	-8.4311
Pb	-.06249181	0.00000771	228.6	-0.0105
Se	-.05889602	0.00339198	234.3	-6.2122
Sb	-.04804751	0.01360235	211.8	90.4321
V	-.06228980	0.00019784	231.9	-0.2860
Zn	-.06085237	0.00155071	221.1	0.1345
DDD	-.06123616	0.00118950	222.4	37.8900

DDE	-.05157907	0.01027853	214.2	261.5
DDT	-.02974763	0.03082576	254.6	-649.4

Table P-11. Vegetated Site - Dip Net Samples Regression models for Macroinvertebrate Numbers

N = 18

Chemical	Adjusted R-square	R-square	Parameter Estimates Intercept	Slope
Al	-.06225895	0.00022687	71.6672	0.000354
*As	0.09699366	0.15011168	101.9	-0.2590
*Ba	0.09696232	0.15008218	130.7	-1.3578
Be	0.04975127	0.10564826	92.2500	-216.3
Ca	-.01376929	0.04586420	83.2601	-0.00135
Cd	0.04975127	0.10564826	92.2500	-154.5
Co	0.02948645	0.08657548	89.9434	-1.4614
Cr	-.01085612	0.04860600	82.8566	-0.0179
Cu	0.01930670	0.07699454	90.8331	-1.2533
Fe	0.03861638	0.09516836	98.9389	-0.00169
Hg	-.02509085	0.03520861	80.4378	-1.5263
K	-.05552811	0.00656178	83.0703	-0.0264
Mg	0.01568625	0.07358706	108.9	-0.0235
Mn	0.04264475	0.09895977	95.4471	-0.0344
*Na	0.12871031	0.17996265	129.5	-0.0962
*Ni	0.06136798	0.11658163	105.7	-2.5207
Pb	0.00094045	0.05970865	92.8030	-0.3683
Se	-.00183854	0.05709314	84.3166	-10.1282
*Sb	0.10806183	0.16052878	52.0000	123.5
V	-.01863705	0.04128278	95.9887	-1.6421
Zn	-.01203194	0.04749935	89.6811	-0.2958
DDD	-.05183523	0.01003743	67.5932	43.7399
DDE	-.06029561	0.00207472	71.7378	46.6803
DDT	-.03955882	0.02159170	83.0295	-216.0

Table P-12. Combined Samples Regression Models for Macroinvertebrate Numbers

N = 36

Chemical	Adjusted R-square	R-square	Parameter Estimates Intercept	Slope
Al	-.02926962	0.00013809	155.5	-0.00059
*As	0.09993455	0.12565071	205.6	-0.5098
Ba	-.02205975	0.00714196	177.7	-0.6372
Be	0.06256181	0.08934576	186.8	-428.0
Ca	-.00974133	0.01910842	163.7	-0.00188
Cd	0.06256181	0.08934576	186.8	-305.7
*Co	0.10881795	0.13428029	193.3	-3.9155
Cr	-.02689286	0.00244694	155.3	-0.00863
Cu	-.02588717	0.00342389	158.7	-0.5686
*Fe	0.09901485	0.12475728	212.0	-0.00417
Hg	-.02940504	0.00000653	151.0	0.0447
K	0.01425663	0.04242073	102.8	0.1446
Mg	-.00162933	0.02698865	196.3	-0.0307
*Mn	0.08717868	0.11325929	200.0	-0.0792
Na	0.03010384	0.05781516	218.5	-0.1173
*Ni	0.09295498	0.11887055	219.5	-5.4759
Pb	-.02589917	0.00341224	160.7	-0.1894
Se	-.02114865	0.00802703	159.3	-8.1702
Sb	-.00262011	0.02602618	131.9	106.9
V	-.02624692	0.00307443	163.9	-0.9641
Zn	-.02862634	0.00076298	155.4	-0.0806
DDD	-.02746790	0.00188833	145.0	40.8150
DDE	-02438516	0.00488299	143.0	154.1
DDT	-.01013823	0.01872286	168.8	-432.7

Multiple regression models for the substrate, vegetation, and combined site data sets were based on the high levels of potentially landfill related inorganic COPCs (As, Ba, Fe, Mn, Ni), as well as those chemicals showing higher R-square values in the simple linear regressions for a data set. The six variable multiple regression model with the

best fit for the substrate samples included arsenic, mercury, manganese, iron, cobalt, and barium (R-square=0.73, Mallow's C(p)=5.7). The six variable model with the best fit for the vegetation samples included mercury, manganese, cobalt, nickel, sodium, and antimony (R-square=0.93, Mallow's C(p)=5.6). The six variable model with the best fit for the combined data set included arsenic, chromium, manganese, iron, cobalt, and barium. These multiple regressions indicate that it is likely that a combination of inorganic COPCs may affect macroinvertebrate abundance in these ponds. It appears that all of the inorganic COPCs in the multiple regressions on the different data sets may impact macroinvertebrate abundance, although cause and effect relationships are not clear.

8.2 Pond Comparison Relating Abundance and COPC Concentrations

The results from the multiple regressions show enough incongruency among data sets that statistical tests among pond and sites within ponds controlling for inorganic chemicals are not reliable. A simpler approach to assessing the difference among ponds is to qualitatively evaluate, through the use of tables and graphs, the levels of inorganic chemicals and the abundance of macroinvertebrates. Table P-13 shows the relationship of mean numbers of macroinvertebrates from substrate, vegetation, and combined sites with levels of arsenic. The landfill column indicates the stations that are adjacent to a landfill. The table shows generally higher levels of arsenic in Plow Shop Pond, with lower levels in Cold Spring Brook Pond, and the lowest levels in Cranberry Pond. The sites nearest the landfill in Plow Shop and Cold Spring Brook Ponds show somewhat higher levels of arsenic. Loosely associated with higher levels of arsenic are lower mean abundances of macroinvertebrates, with Plow Shop Pond having the lowest macroinvertebrate abundance of the ponds, and the lowest numbers within the pond near the landfill sites.

Table P-13. Mean macroinvertebrate numbers versus arsenic levels

Landfill µg/g	Pond	Vegetation Organisms Station	Substrate Organisms #/Sq. Meter	Combined Organisms #/Sq. Meter	Arsenic #/Sq. Meter
	COLD CS-1	268	362	354.50	15.00
	COLD CS-1	297	491		15.00
L	COLD CS-2	52	12	113.00	11.90
L	COLD CS-2	30	358		11.90
L	COLD CS-3	28	186	101.50	280.00
L	COLD CS-3	37	155		280.00
	CRAN CP-1	137	34	71.75	6.50

	CRAN CP-1	21	95		6.50
	CRAN CP-2	80	130	185.25	13.80
	CRAN CP-2	83	448		13.80
	CRAN CP-3	43	709	295.00	3.85
	CRAN CP-3	31	397		3.85
	PLOW PS-1	43	253	169.50	170.00
	PLOW PS-1	35	347		170.00
L	PLOW PS-2	38	53	47.75	150.00
L	PLOW PS-2	42	58		150.00
L	PLOW PS-3	37	8	22.25	310.00
L	PLOW PS-3	34	10		310.00

Graphs were also used to evaluate these data. Figures P-2, P-3, and P-4 plot the mean number of macroinvertebrates for vegetation, substrate, and combined sites respectively with the three inorganic chemicals having the highest simple linear regression R-square for the accompanying data set. Figure P-2 plots mean numbers of macroinvertebrates versus levels of arsenic for the vegetation samples from each of the three stations in the three ponds. Stations in Plow Shop Pond and Cold Spring Brook Pond nearest landfills are indicated with an L on the plot. Stations nearest the landfill generally have lower numbers of macroinvertebrates. Some of the landfill sites in both ponds have high levels of arsenic, but Cold Spring Brook Pond has one site near a landfill with both low levels of arsenic and low macroinvertebrate abundance. Figure P-2 indicates the same loose association of high arsenic levels and low macroinvertebrate abundance as Table P-13, with Plow Shop Pond showing the highest arsenic levels and low macroinvertebrate abundance. Figure P-3 plots mean macroinvertebrate abundance from substrate samples against cobalt levels. Symbols marked with an L indicate stations closest to the landfill. The two sites adjacent to the landfill at Plow Shop Pond show the highest levels of cobalt and the lowest macroinvertebrate abundance. The two sites adjacent to the landfill in Cold Spring Brook Pond have low levels of cobalt and moderate numbers of macroinvertebrates. The site furthest from the landfills in Plow Shop Pond has fairly high macroinvertebrate abundance. The levels of cobalt at Cranberry Pond are minimal, but the macroinvertebrate abundance spans the range from low to high. These data indicate a possible loose association of cobalt levels and macroinvertebrate abundance, but are also indicative that it is a combination of inorganic chemicals that may be impacting macroinvertebrate abundance. The combined site data in Figure P-4 showing mean macroinvertebrate abundance versus nickel levels is most indicative of decreasing abundance with increasing nickel levels. Both sites adjacent to landfills in Plow Shop Pond and one of the sites near the landfill in Cold Spring Brook Pond show declining macroinvertebrate numbers with increasing nickel

concentrations. The site near a landfill at Cold Spring Brook Pond with low nickel concentrations and moderate macroinvertebrate numbers, together with the two low nickel concentration and low to moderate macroinvertebrate abundance sites in Cranberry Pond, weaken the apparent association between nickel levels and macroinvertebrate abundance.

The tabular and graphical data suggest the same result as the simple linear and multiple regressions. No single inorganic chemical is reducing macroinvertebrate abundance, but a group of inorganic COPCs may be impacting the macroinvertebrate populations. An interesting observation from reviewing Figures P-2, P-3, and P-4 is that by looking at substrate and vegetation macroinvertebrates separately, it appears that different chemicals are having the primary impact on the macroinvertebrates. When the data are combined across substrate and vegetation, a different chemical than seen at the separate locations appears to impact most strongly on macroinvertebrate abundance. These results are all supportive of the hypothesis that a group of inorganic chemicals may be reducing macroinvertebrate abundance.

8.3 Metrics and Sediment Chemistry

The analyses of the relationship between sediment chemistry and the five metrics were performed using the same methods (simple linear and multiple regression) on metrics from substrate, vegetation, and combined samples. The results from these analyses showed great variation among the metrics in the strength of the relationship, as measured by R-square. The metric for the ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae numbers was not interpretable because of the low R-squares combined with slopes for the highest R-squares being both positive and negative. The remaining four metrics showed moderate to fairly strong relationships with inorganic chemicals. The analyses of data sets for substrate, vegetation, and combined samples showed variation in the strength and key chemicals in the different data sets. The metrics for the combined samples (metrics calculated by station) consistently exhibited higher R-squares with individual inorganic chemicals. The metrics for the combined samples also had key chemicals that were more consistent with the analyses of macroinvertebrate abundance. The metrics for taxa richness, numbers of Ephemeroptera, Plecoptera, and Trichoptera (EPT Index), Biotic Index, and percent dominant taxon using the combined sample (by station) analysis are used in the ensuing discussion because they provided the most informative indicators of the relationship of metrics with inorganic chemicals levels.

8.3.1 Taxa Richness

Table P-14 shows the simple linear regression model relationship of taxa richness and COPC levels. The R-square for nickel of 58% indicates a possible relationship between increasing nickel levels and declining taxa richness (negative slope = -0.466). The key inorganic COPCs (Ni, Co, Fe, Mn, As) impacting on taxa richness are consistent with those seen in the macroinvertebrate abundance analysis. The COPC chosen for multiple regression model fitting were the same as used in the macroinvertebrate abundance models, with the addition of a few chemicals demonstrating high R-squares with the metrics. There was high multicollinearity in the multiple regression models for the metrics which makes selection of any one model difficult. The best six variable model for taxa richness (R-square=0.997) includes nickel, arsenic, barium, calcium, cobalt, and zinc. These analyses seem to indicate the key chemicals which may be affecting taxa richness are nickel, arsenic, cobalt, iron, calcium, manganese, barium, and zinc.

Table P-14. Regression Models for Taxa Richness with Metrics by Station
N = 9

			Parameter Estimates	
Chemical	**Adjusted R-square**	**R-square**	**Intercept**	**Slope**
Al	-.10614579	0.03212243	34.8281	0.000347
*As	0.27941449	0.36948768	40.9092	-0.0335
Ba	-.14284419	0.00001134	37.2929	0.000972
Be	0.19908815	0.29920213	39.8333	-30.0000
Ca	-.09524465	0.04166093	38.0431	-0.00011
Cd	0.19908815	0.29920213	39.8333	-21.4286
*Co	0.39024924	0.46646808	40.3404	-0.2795
Cr	-.13702651	0.00510180	37.5638	-0.00048
Cu	-.14113008	0.00151118	37.5251	-0.0145
*Fe	0.30290111	0.39003847	41.4566	-0.00028
Hg	-.14211311	0.00065103	37.2637	0.0171
K	0.0162515	0.13919701	33.9752	0.0100
Mg	0.09024619	0.20396541	42.0908	-0.00323
*Mn	0.30150810	0.38881959	40.8002	-0.00562

Na	-.06122946	0.07142422	40.2008	-0.00499
*Ni	0.52867359	0.58758939	43.1499	-0.4663
Pb	-.14000689	0.00249397	37.0204	0.00620
Se	-.12896114	0.01215900	37.7172	-0.3852
Sb	-.14133739	0.00132979	37.5000	-0.9259
V	-.13455077	0.00726808	36.5807	0.0568
Zn	-.14285629	0.00000074	37.3283	0.000096
DDD	-.07874946	0.05609422	36.0420	8.5206
DDE	0.02519828	0.14704849	35.6098	32.3840
DDT	-.13973194	0.00273455	37.5916	-6.3338

8.3.2 EPT Index

Table P-15 shows the simple linear regression model relationships of the EPT index and inorganic COPC levels. Arsenic and mercury appear to have the strongest relationship with the EPT index (R-square = 0.27), both with negative slopes indicating a decrease in the EPT Index with increasing chemical levels. The key inorganic chemicals (Hg, As, Mn, Ca, Co) again overlap with key chemicals seen in the macroinvertebrate abundance analyses, but differ slightly from the key chemicals for taxa richness. There are two equally good six variable multiple regressions for the EPT index (R-square = 0.998) including mercury, manganese, arsenic, chromium, iron, and either beryllium or cadmium. These analyses indicate that mercury, arsenic, manganese, chromium, iron, cobalt, beryllium, and cadmium may impact on the abundance of Ephemeroptera, Plecoptera, and Trichoptera.

Table P-15. Regression Models for EPT Index with Metrics by Station

N = 9

Chemical	Adjusted R-square	R-square	Parameter Estimates: Intercept	Parameter Estimates: Slope
Al	-.11530070	0.02411189	4.6617	0.000093
*As	0.16849568	0.27243372	6.2834	-0.00890
Ba	-.14255655	0.00026302	5.2731	0.00145
Be	-.12698413	0.01388889	5.5000	-2.0000

*Ca	0.10495185	0.21683287	5.8344	-0.00007
Cd	-.12698413	0.01388889	5.5000	-1.4286
*Co	0.08282109	0.19746845	5.9387	-0.0563
Cr	0.00665567	0.13082371	4.9721	0.000748
Cu	0.00594592	0.13020268	4.7826	0.0416
Fe	0.04119846	0.16104865	6.1532	-0.00006
*Hg	0.07509300	0.19070638	4.9645	0.0906
K	0.05349607	0.1780906	4.1789	0.00345
Mg	0.16850455	0.27244149	7.0347	-0.00115
*Mn	0.11832714	0.22853625	6.1558	-0.00133
Na	-.09252205	0.04404321	6.0301	-0.00121
Ni	0.05185455	0.17037273	6.3025	-0.0777
Pb	-.01672005	0.11036996	4.6892	0.0128
Se	-.08522339	0.05042954	5.5752	-0.2427
Sb	0.00000000	0.12500000	5.8333	-2.7778
V	-.09315181	0.04349216	4.7637	0.0430
Zn	0.02930733	0.15064391	4.6314	0.0134
DDD	-.14284762	0.00000833	5.3285	0.0321
DDE	-.13339838	0.00827642	5.2068	2.3773
DDT	-.03408708	0.09517381	5.8048	-11.5622

8.3.3 Biotic Index

Table P-16 shows the simple linear regression model relationship of the biotic index and inorganic COPC levels. It is important to note that the biotic indices employed in this evaluation were generally developed for organic contaminants, and there is therefore considerable uncertainty associated with this metric analysis at the 1A sites. The chemicals iron, manganese, and cobalt all show a fairly strong relationship with the biotic index (R-square > 0.66). The positive slopes indicate the biotic index increases with increasing chemical levels, which is associated with the fact that larger biotic indices indicate organisms with greater pollution tolerance. The key inorganic chemicals (Fe, Mn, Co, Cd, Be) are consistent with the macroinvertebrate abundance analyses. Two six variable multiple regression models relate with the biotic index equally as well (R-square = 0.993). The inorganic chemicals in the model are

mercury, manganese, arsenic, iron, zinc, and cadmium or beryllium. The multiple regression model for the biotic index differs by one metal (zinc for chromium) from the model for the EPT index. It appears that mercury, manganese, arsenic, iron, zinc, cobalt, cadmium, and beryllium may affect the biotic index.

Table P-16. Regression Models for the Biotic Index with Metrics by Station
N = 9

Chemical	Adjusted R-square	R-square	Parameter Estimates Intercept	Slope
Al	-.02330696	0.10460641	7.0306	-0.00003
As	0.32821352	0.41218683	6.6602	0.00158
Ba	-.14214499	0.00062313	6.8154	0.000322
*Be	0.45266930	0.52108564	6.6815	1.7672
Ca	-.13943940	0.00299053	6.8373	-1.27E-6
*Cd	0.45266930	0.52108564	6.6815	1.2623
*Co	0.61157422	0.66012745	6.6691	0.0148
Cr	-.04403221	0.08647181	6.7864	0.000088
Cu	-.05633481	0.07570704	6.7682	0.00457
*Fe	0.66018064	0.70265806	6.5817	0.000017
Hg	-.06424571	0.06878501	6.7968	0.00785
K	0.03691809	0.15730333	6.9881	-0.00048
Mg	-.07705048	0.05758083	6.9416	-0.00008
*Mn	0.61989962	0.66741217	6.6260	0.000329
Na	-.10478204	0.03331572	6.7414	0.000152
Ni	0.30797007	0.39447382	6.6160	0.0171
Pb	-.05125561	0.08015134	6.7496	0.00157
Se	-.14218815	0.00058537	6.8325	-0.00377
Sb	-.11431294	0.02497618	6.8610	-0.1791
V	-.11352811	0.02566290	6.8919	-0.00476
Zn	-.06888087	0.06472924	6.7624	0.00127
DDD	-.10178518	0.03593797	6.7826	0.3044
DDE	-.13422388	0.00755411	6.8462	-0.3276
DDT	-.02969043	0.09902088	6.7594	1.7013

8.3.4 Percent Dominant Taxon

Table P-17 shows the simple linear regression model relationship of the percent dominant taxon and chemical levels. Manganese and mercury have the strongest apparent relationship to the percent dominant taxon (R-square = 0.43). The percent dominant taxon generally increases with chemical levels, indicating that larger numbers of taxa tolerant to the chemicals may successfully be able to inhabit those sites. The key inorganic chemicals are (Mn, Hg, Cr, Fe, As) which appear consistently related in the metric analyses. Two models with six variables show equally good fits to the percent dominant taxon metric (R-square = 0.999). The models include the chemicals arsenic, calcium, cobalt, copper, zinc, and either cadmium or beryllium. These analyses indicate that manganese, mercury, chromium, arsenic, calcium, cobalt, copper, iron, zinc, cadmium, and beryllium may impact on the percentage of the dominant taxon.

Table P-17. Regression Models for the Percent Dominant Taxon with Metrics by Station

N = 9

			Parameter Estimates	
Chemical	**Adjusted R-square**	**R-square**	**Intercept**	**Slope**
Al	0.10181738	0.21409021	0.3597	-0.00001
As	0.20638133	0.30558367	0.2310	0.000403
Ba	0.02590108	0.14766345	0.2129	0.00147
Be	0.19240955	0.29335836	0.2413	0.3935
Ca	-.13442998	0.00737377	0.2701	5.918E-7
Cd	0.19240955	0.29335836	0.2413	0.2811
Co	0.08976193	0.20354169	0.2478	0.00245
*Cr	0.26900512	0.36037948	0.2484	0.000053
Cu	0.21706856	0.31493499	0.2374	0.00277
*Fe	0.26361857	0.35566625	0.2219	3.572E-6
*Hg	0.34432988	0.42628864	0.2505	0.00580
K	-.14266564	0.00016757	0.2725	4.611E-6
Mg	-.13985418	0.00262759	0.2812	-4.85E-6

*Mn	0.35460763	0.43528168	0.2255	0.000079
Na	-.10823440	0.03029490	0.2493	0.000043
Ni	0.05546597	0.17353273	0.2322	0.00336
Pb	0.05891612	0.17655161	0.2392	0.000691
Se	-.02459051	0.10348330	0.2592	0.0149
Sb	-.13713944	0.00500299	0.2698	0.0238
V	-.11404231	0.02521298	0.2926	-0.00140
*Zn	0.22326473	0.32035664	0.2302	0.000839
DDD	-.12921276	0.01193883	0.2820	-0.0521
DDE	-.07183080	0.06214805	0.2889	-0.2789
DDT	-.11427777	0.02500695	0.2637	0.2537

8.4 SUMMARY OF SEDIMENT CHEMISTRY AND MACROINVERTEBRATES ANALYSIS

The analyses of the relationship of sediment chemistry and the abundance and diversity (metrics) of macroinvertebrates indicate that no single chemical seems to be determinant of the macroinvertebrate communities at different ponds or at sites within ponds. There is essentially no relationship between levels of organic pesticides (DDD, DDE, and DDT) and differences in macroinvertebrate abundance and diversity in the study ponds. It appears that a group of approximately 15 inorganic chemicals may impact on the macroinvertebrate community (arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, mercury, manganese, sodium, nickel, antimony, zinc). The five key inorganic chemicals that may collectively affect macroinvertebrate abundance are arsenic, cobalt, iron, manganese, and nickel. The five key inorganic chemicals appearing to affect macroinvertebrate diversity metrics are arsenic, cobalt, iron, manganese and mercury. These five COPCs tend to surface as potential stressors on the macroinvertebrate abundance and diversity in the multiple regression analyses conducted in this study. Although not a major factor in the simple linear regressions, mercury was a key COPC in virtually all multiple regression diversity models, indicating that mercury may be affecting the community diversity in the subject ponds. All key COPCs have been demonstrated in other studies to affect mortality, reproduction, and growth of aquatic organisms. For instance, evidence exists suggesting that larval chironomids are sensitive to nickel in sediments (Baudo et al., 1990). Exposure to nickel has also been shown to result in immobilization, mortality, reproductive impairment, and growth inhibition in select invertebrates (USEPA, 1980). According to USEPA (1985), effects

associated with invertebrate exposure to mercury are diverse, and include reduced population density, reduced growth rate, and reproductive impairment. Ferric and ferrous iron precipitates may cause a variety of endpoint effects, including: gill coating (reduction in respiratory capabilities), decreased birth rate (smothering of eggs), decreased food availability (smothering bottom-dwelling food items), and immobilization of microorganisms and algae and physical transport via water currents (Baudo et al., 1990). Observed endpoint-effects associated with exposure to inorganic arsenic include growth inhibition, reproductive effects, and mortality (USEPA, 1984).

Plow Shop Pond has the highest levels of key inorganic chemicals and also may have the greatest reduction in macroinvertebrate abundance and diversity. The macroinvertebrate collection sites closest to landfills show a weak qualitative association between higher inorganic COPC levels and lower macroinvertebrate abundance. These analyses do not show a clear cause and effect relationship between inorganic COPC levels and impacts on macroinvertebrate abundance and diversity. However, this analysis does help to focus on those inorganic analytes that could be analyzed in future studies to further assess the relationship between sediment chemistry and macroinvertebrate communities in the study ponds at Fort Devens Group 1A sites.

9.0 SUMMARY AND CONCLUSION

Three ponds at Fort Devens, Massachusetts were sampled for benthic macroinvertebrates to assess macroinvertebrate community differences and similarities within and among ponds, and to assess whether two nearby landfills may have impacted the community structures within the ponds. New Cranberry Pond was used as the reference site, and Plow Shop Pond and Cold Spring Brook Pond were examined as the potentially impacted sites. Three stations were sampled at each of the three ponds, and macroinvertebrates were collected from both vegetated and non-vegetated substrates, using mesh dip nets and Eckman dredges, respectively. Collected macroinvertebrates were preserved in ethanol and identified to species or the lowest taxonomic level possible.

The following metrics were calculated for the vegetated and non-vegetated substrate samples: taxa richness, modified family biotic index (FBI), ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomidae (EPT/C), percent contribution of the dominant family, and the EPT index (Tables P-1a, P-2a, P-3a

and P-1b, P-2b, P-3b). In addition, a Jaccard Coefficient of similarity (Table P-6), statistical analysis of macroinvertebrate abundance(Tables P-7,P-8, and P-9), and a cluster analysis were done on the data (Figure P-1). Finally, a percent comparability ratio was calculated as suggested in the EPA Rapid Bioassessment Protocol III (Tables P-4 and P-5).

The results of the five metrics indicated that Plow Shop Pond had a significantly lower taxa richness than the other two ponds. New Cranberry Pond, the reference site, had the highest taxa richness of the three ponds (Tables P-2a and P-2b).

New Cranberry Pond also had a significantly lower FBI than the other two ponds in the vegetated substrate. This indicates that New Cranberry Pond has more pollution intolerant species than the other two ponds. Plow Shop Pond had a significantly higher percentage of pollution-tolerant dominant taxa in the vegetated substrate, and Cold Spring Brook showed a similar result for the non-vegetated substrates, indicating that both ponds may be impacted relative to New Cranberry Pond.

The RBP-III percent comparability analysis indicated that Plow Shop Pond may have a suboptimal macroinvertebrate community structure (Table P-4). Cold Spring Brook Pond was non-impaired according to this analysis; however, other tests indicated that Cold Spring Brook Pond, while not as impacted as Plow Shop Pond, may still be slight impacted relative to New Cranberry Pond.

The Jaccard Coefficients show that the stations sampled closest to the landfills had reductions in macroinvertebrate communities, and were most similar to each other (Table P-6). Stations farthest from the landfills had greater macroinvertebrate biodiversity, and were also quite similar. Statistics done on the abundance of macroinvertebrates showed a similar result: Plow Shop Pond may be the most impacted, and the stations nearest to the landfills in both Plow Shop Pond and Cold Spring Brook Pond had reduced macroinvertebrate abundance (Table P-8). Analysis of macroinvertebrate abundance of different orders among ponds showed significant reductions in the diptera and Cladocera at Plow Shop Pond (Table P-9). There were also more orders of macroinvertebrates not represented in collections at Plow Shop Pond than from Cold Spring Brook and New Cranberry Ponds.

The results of the cluster analysis were in accordance with the preceding analyses. The cluster analysis suggests that the closer a station within a pond is to a landfill, the greater the impact to the macroinvertebrate community (Figure P-1). Similar effects were observed in Plow Shop Pond and Cold Spring Brook Pond, with reductions in both the number of taxa and the abundance of individuals within the taxa at stations nearest the landfills.

The analyses of the relationship of sediment chemistry and the abundance and diversity (metrics) of macroinvertebrates indicate that no single chemical seems to be determinant of the macroinvertebrate communities at different ponds or at sites within the ponds. There is essentially no relationship between levels of organic pesticides (DDD, DDE, and DDT) and differences in macroinvertebrate abundance and diversity in the study ponds. It appears that a group of approximately 15 inorganic chemicals may impact on the macroinvertebrate community (arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, mercury, manganese, sodium, nickel, antimony, and zinc). The five key inorganic chemicals that may collectively affect macroinvertebrate abundance are arsenic, cobalt, iron, manganese, and nickel. The five key inorganic chemicals appearing to affect macroinvertebrate diversity metrics are arsenic, cobalt, iron, manganese and mercury. These 5 COPCs tend to surface as potential stressors on the macroinvertebrate abundance and diversity in the multiple regression analyses conducted in this study.
Plow Shop Pond's macroinvertebrate community may be more impacted than that of Cold Spring Brook Pond, which may also be somewhat disturbed. The data suggest that the macroinvertebrate sampling stations closest to either landfill may be more impacted relative to stations furthest from the landfills.

Plow Shop Pond's macroinvertebrate community may be slightly impacted relative to that of New Cranberry Pond, the reference pond.

9.1 MACROINVERTEBRATE PROGRAM UNCERTAINTY

The data suggest that the macroinvertebrates inhabiting the water column may be more impacted than those dwelling in the sediments. This conclusion does not make intuitive sense, given the high levels of sediment contamination and the relatively low levels of surface water contamination. Based on the known contaminant distribution the infauna (exposed primarily to the sediments) in non-vegetated areas would be expected to exhibit greater effects than the epifauna in

vegetated areas (exposed primarily to the surface water). While considerable uncertainty is associated with the Fort Devens macroinvertebrate study, several possible explanations for this phenomenon exist. Organisms inhabiting the water column may spend a significant portion of their life history in contact the sediments, particularly during seasons when the plant community in the subject ponds is not fully developed. Alternatively, it is conceivable that this finding is an artifact of the sampling regime. The Ekman dredges used to sample the bottom substrate covers a surface area of approximately 0.05 square meters, whereas the macroinvertebrates from the vegetation were collected from a 1 square meter plot. Although all samples were normalized per unit area, it is conceivable that this sampling program could result in the counter intuitive findings. Lastly, it is important to note that a statistical analysis of the data identifies quantitative relationships and correlations; it does not imply causal relationships. Unless all physicochemical and biological parameters other than contaminants are identified, it is difficult to demonstrate that sediment or surface water contaminants are affecting the macroinvertebrate communities.

The macroinvertebrate program at the Fort Devens Group 1A sites was designed to provide baseline information regarding the biota associated with aquatic habitats at Plow Shop Pond, and to provide baseline information for possible use in the evaluation of effects and effectiveness of any future remedial actions. Considerable uncertainty is associated with the interpretation of the results of the Group 1A macroinvertebrate study. Limited numbers of samples, uncertainties with the reference pond, differences in habitat types between ponds, and natural environmental stochasticity confound interpretation of the portion of the supplemental risk assessment. Additional information regarding uncertainties is contained in Section 7.3 of the RI Addendum Report. It is important to recognize that, although the statistical analysis identifies quantitative correlations and relationships, it does not identify causal relationships. It is entirely possible that numerous factors, including factors and parameters not identified in this analysis, may be affecting the macroinvertebrate abundance and diversity at the evaluated ponds. Unless all physicochemical parameters, other than contaminants, are identified, it is difficult to demonstrate that sediment contaminants are affecting macroinvertebrate communities.

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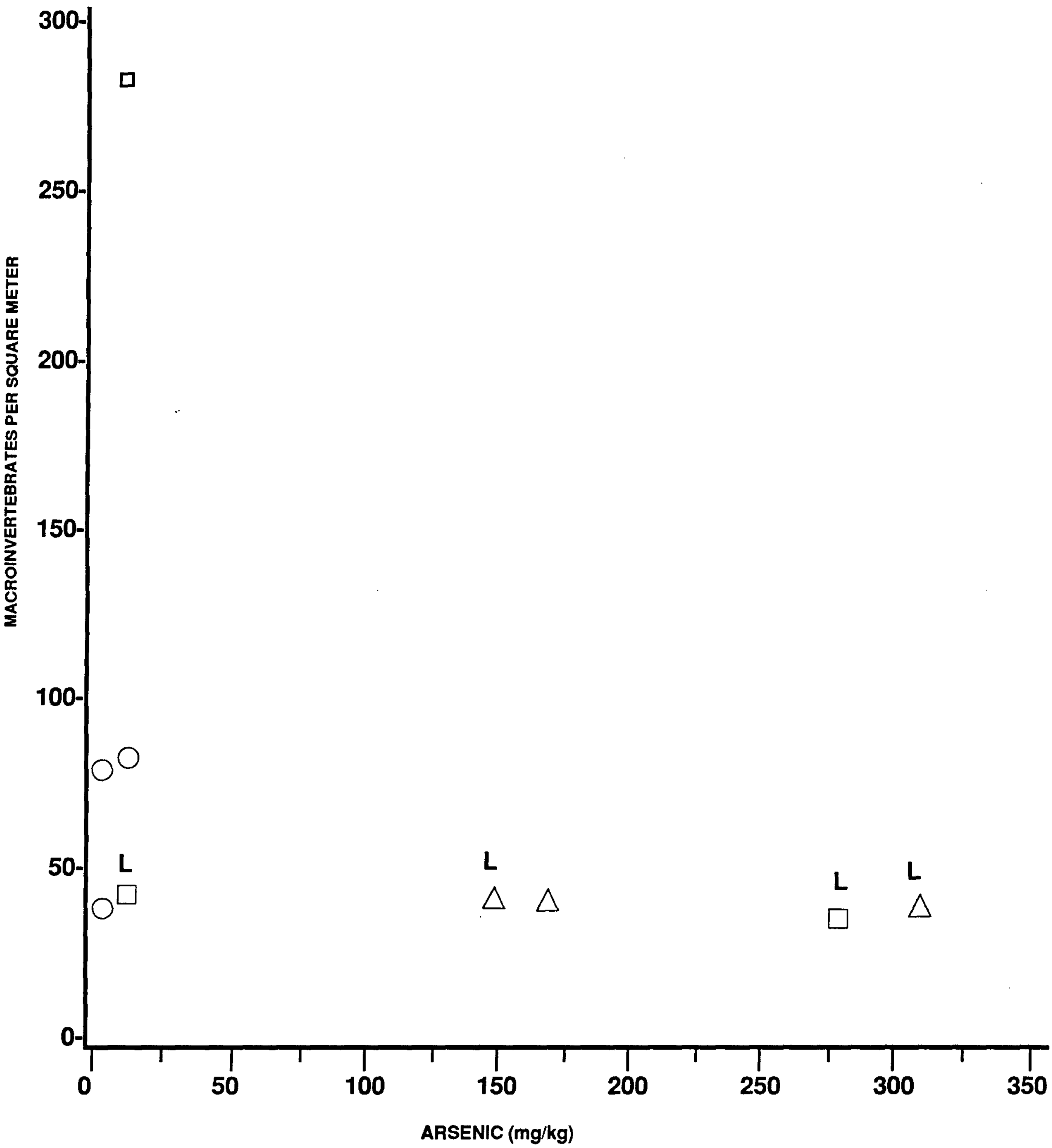


POND:
- COLD SPRING BROOK POND (□)
- NEW CRANBERRY POND (○)
- PLOW SHOP POND (△)

FIGURE P-2
COMPARISON OF POND MACROINVERTEBRATES
VERSUS ARSENIC LEVELS, DIP NET SAMPLES FROM VEGETATION
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

ABB Environmental Services, Inc.

7005-08 B

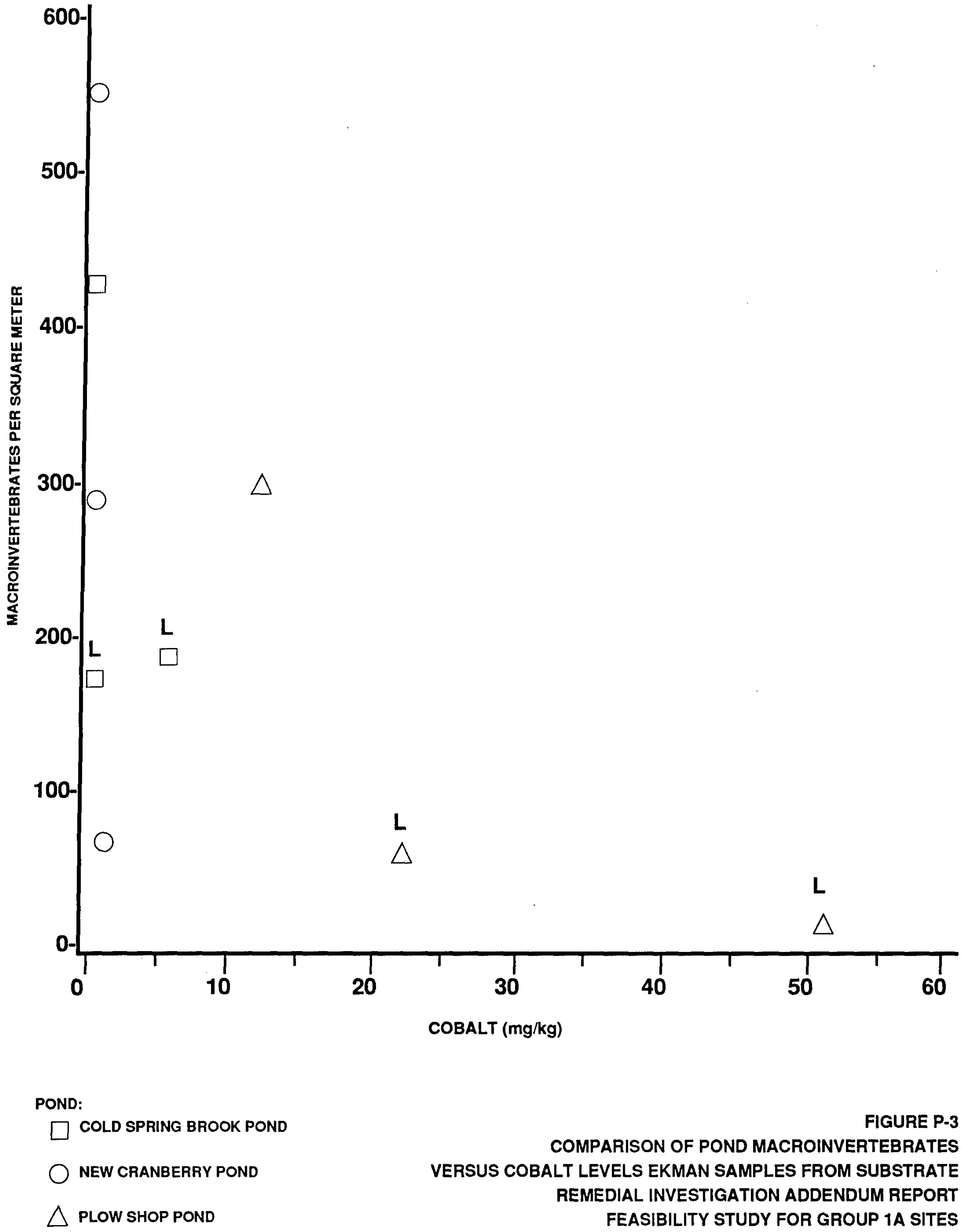
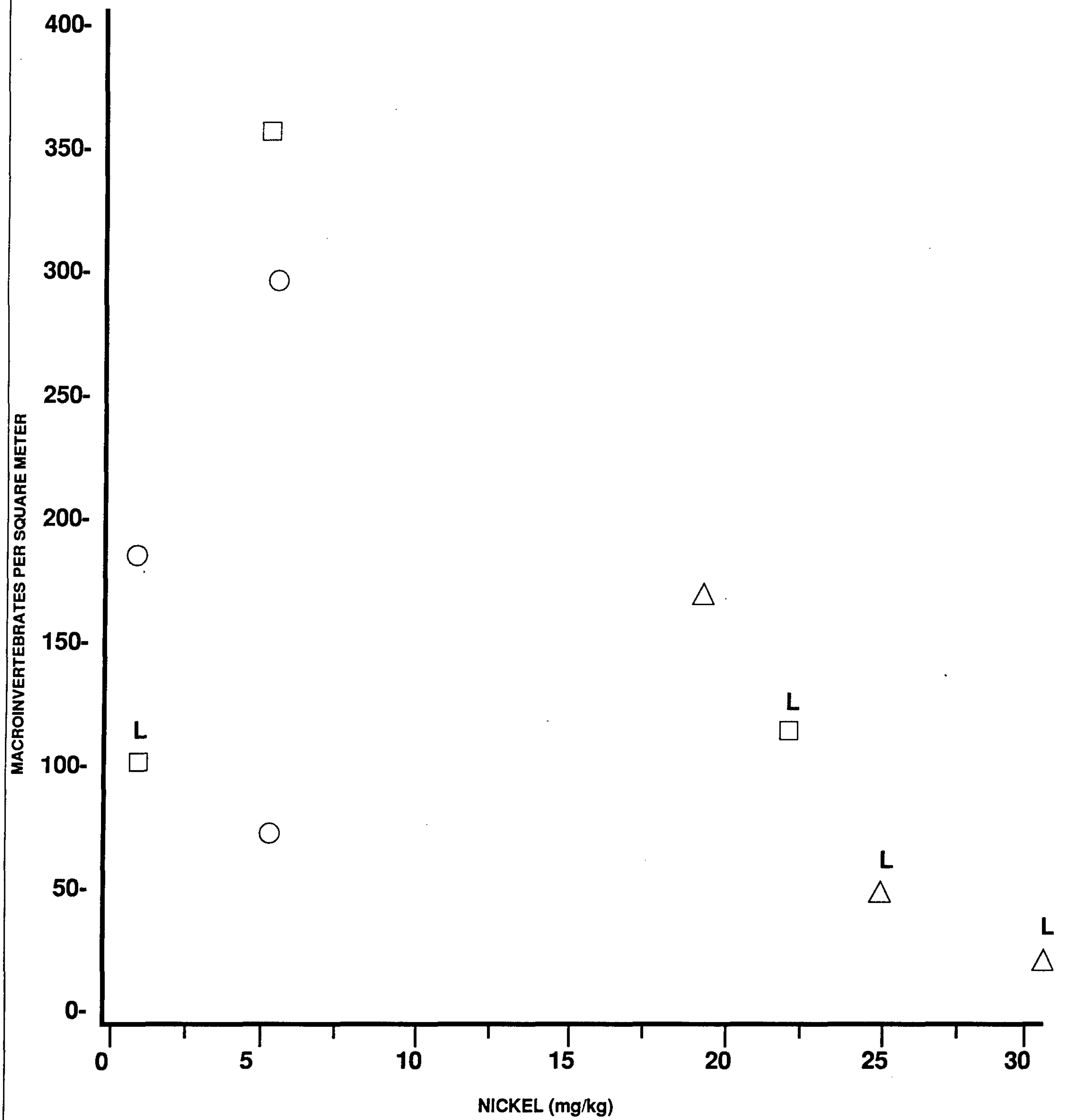


FIGURE P-3
COMPARISON OF POND MACROINVERTEBRATES
VERSUS COBALT LEVELS EKMAN SAMPLES FROM SUBSTRATE
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

ABB Environmental Services, Inc.

7005-08 B



POND:
- COLD SPRING BROOK POND (square)
- NEW CRANBERRY POND (circle)
- PLOW SHOP POND (triangle)

FIGURE P-4
COMPARISON OF POND MACROINVERTEBRATES
VERSUS NICKEL LEVELS, COMBINED VEGETATION AND SUBSTRATE SAMPLES
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

ABB Environmental Services, Inc.

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ECOLOGICAL RISK ASSESSMENT PARAMETERS

Table Q-1
Ecological Exposure Parameters

Remedial Investigation Addendum Report
Feasibility Study for Group 1A Sites
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RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Muskrat (*Ondatra zibethicus*)	Home Range (acres)	26 acres	DeGraaf and Rudis, 1983	26 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 100%	Conservative estimate (Assumes year-round foraging activity)	100%
	Percent Prey Items	>80% Plants Fish and Invertebrates	Allen and Hoffman, 1984 (in E & E, 1993)	Plants: 87% Fish: 5% Invertebrates: 5% Sediment: 3%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for all species. F= 0.056*W^0.6611	USEPA, 1988	0.065 kg/day
	Body Weight (kg)	1.25 kg	Godin, 1977	1.25 kg

Table Q–1
Ecological Exposure Parameters

Remedial Investigation Addendum Report
Feasibility Study for Group 1A Sites
Fort Devens, MA

RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Raccoon *(Procyon lotor)*	Home Range (acres)	1,150 acres	DeGraaf and Rudis, 1983	1,150 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 100%	Conservative estimate	100%
	Percent Prey Items	Plants 31% Fish, Reptiles, Amphibians, Invertebrates, Mammals, Birds	Martin et al., 1951	Plants: 31% Invertebrates: 25% Fish: 9% Reptiles and Amphibians: 20% Mammals: 9% Birds: 1% Sediment: 5%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for all species. F= 0.056*W^0.6611	USEPA, 1988	0.221 kg/day
	Body Weight (kg)	7.95 kg	Godin, 1977	7.95 kg

Table Q-1
Ecological Exposure Parameters

Remedial Investigation Addendum Report
Feasibility Study for Group 1A Sites
Fort Devens, MA

RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Mallard *(Anas platyrhynchos)*	Home Range (acres)	1,285 acres, at beginning of breeding season (assume site acreage)	DeGraaf and Rudis, 1983	30 acres: PSP 3.5 acres: CSBP
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 50%	E & E, 1993	50%
	Percent Prey Items	Rooted and Floating Plants Invertebrates	Martin et al., 1951	Plants: 87% Invertebrates: 11% Sediment: 2%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for chickens. F= 0.075 * W ^0.8449	USEPA, 1988	0.086 kg/day
	Body Weight (kg)	1.247 kg, Male 1.107 kg, Female 1.193 Juvenile Male 1.048 Juvenile Female	Bellrose, 1978 (in E & E, 1993)	1.177 kg

Table Q–1
Ecological Exposure Parameters

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RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Great Blue Heron *(Ardea herodias)*	Home Range (acres)	Assume 100 acres	Conservative estimate	100 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 50 %	E & E, 1993	50 %
	Percent Prey Items	75% Fish 4% Reptiles and Amphibians 16% Invertebrates 5% Mammals	Martin et al., 1951	Fish: 70% Invertebrates 16% Reptiles and Amphibians 4% Mammals 5% Sediment: 5%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for chickens. F= 0.075 * W ^0.8449	USEPA, 1988	0.187 kg/day
	Body Weight (kg)	2.95 kg	Palmer, 1962	2.95 kg

Table Q-1
Ecological Exposure Parameters

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RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Mink *(Mustela vison)*	Home Range (acres)	19.3 to 50.4 acres Average range is 2 -3 miles	DeGraaf and Rudis, 1983	35 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 100 %	Conservative estimate	100 %
	Percent Prey Items	Small mammals, particularly muskrats, voles, rabbits, fish, crayfish, and insects	DeGraaf and Rudis, 1983	Invertebrates: 20% Fish: 52% Small mammals: 25% Sediments: 3%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for all species. F= 0.065 * W ^0.7919	USEPA, 1988	0.055 kg/day
	Body Weight (kg)	0.565 - 1.25 kg (male) 0.5 - .95 kg (female)	Baker, R.H., 1983	0.8 kg

Table Q–1
Ecological Exposure Parameters

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RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Green Frog *(Rana clamitans)*	Home Range (acres)	Assume 0.5 acres	Conservative estimate	0.5 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 75 %	Conservative estimate	75 %
	Percent Prey Items	Plants, Fish, Amphibians	Hamilton, 1948 (in E & E, 1993)	Plants: 10% Invertebrates: 70% Fish 10% Amphibians: 7% Sediment: 3%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for all species. $F= 0.065 * W ^{0.7919}$	USEPA, 1988	0.005 kg/day
	Body Weight (kg)	0.037 kg	Altman and Dittmer, 1962 (in E & E, 1993)	0.037 kg

Table Q-1
Ecological Exposure Parameters

Remedial Investigation Addendum Report
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Fort Devens, MA

RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Painted Turtle *(Chrysemys picta)*	Home Range (acres)	12 acres	DeGraaf and Rudis, 1983	12 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 75 %	Conservative estimate	75 %
	Percent Prey Items	39% Plants (24% rooted/ 15% floating) Fish and Invertebrates	Ernst and Barbour, 1972	Fish: 13% Plants: 39% Invertebrates: 43% Sediment: 5%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for all species. $F = 0.065 * W ^{0.7919}$	USEPA, 1988	0.056 kg/day
	Body Weight (kg)	0.834 kg (weight of pond slider)	Altman and Dittmer, 1962 (in E & E, 1993)	0.834 kg

Table Q-1
Ecological Exposure Parameters

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RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUE SELECTED FOR ECOLOGICAL RISK
Osprey *(Pandion haliaetus)*	Home Range (acres)	Assume 100 acres	Conservative estimate	100 acres
	Exposure Duration Factor (% of time at site due to seasonal use)	Assume 5% of year (18 days)	Conservative estimate	5%
	Percent Diet	Fish (staple), occasionally snakes and birds	Terres, 1987	Fish: 100%
	Ingestion Rate (kg/day)	Allometric relationship between body weight (W) and food ingestion rate (F) for chickens: F= 0.075 * W ^0.8449	USEPA, 1988	0.094 kg/day
	Body Weight (kg)	1.06 to 1.59 kg	Terres, 1987	1.3 kg [a]

[a] Average of reported values

Table Q-2

Bioaccumulation Factors

In order to model food chain exposures to COPCs in sediment and fish tissue, tissue residues in prey items (invertebrates, fish, amphibians, reptiles, small birds, and small mammals) were estimated using bioaccumulation factors (BAFs). BAFs for COPCs in Plow Shop Pond sediments are presented in Table Q-2a, while those for the COPCs in Cold Spring Brook Pond sediments are presented in Table Q-2b. The approach and rationale used to derive the BAFs shown in these two tables is discussed below. Recent studies have indicated that the magnitude of fish tissue contaminant burden may not be directly related to the magnitude of sediment contamination (Weiner, 1993). It is likely that other factors, including fish lipid content, trophic level of the organisms evaluated, and trophic status of the aquatic resource evaluated, may explain ecological partitioning of contaminants in aquatic systems (Rowan and Rasmussen, 1992). Nonetheless, for the purpose of modeling ecological exposure to contaminants at Plow Shop Pond and Cold Spring Brook Pond, BAFs that model direct uptake from sediments were assumed to play a major role in trophic transfer processes.

Fish BAFs. Empirical data were available for many of the COPCs from the site-specific fish tissue study. For these COPCs, analyte-specific BAF_{fish} were established by dividing the average whole-body fish tissue concentration by the average sediment concentration in each pond. Rather than calculate a second BAF for the RME evaluation, the established BAF_{fish} was multiplied by the maximum sediment concentration to establish the RME fish tissue concentration. Thus the established BAF_{fish} was used to establish a realistic RME fish tissue concentration.

Several analytes were undetected in fish tissue, but were found in sediments; conversely, several other analytes were detected in fish tissue, but were undetected in sediments. In these cases, a value one-half the fish tissue or sediment SQL was used to estimate the BAF. Fish tissues were not analyzed for SVOCs (e.g., PAHs), and therefore site-specific BAFs could not be calculated for these chemicals. The BAFs derived from the literature for terrestrial invertebrates were used to estimate fish tissue concentrations for SVOCs.

BAFs for Other Vertebrate Prey Items. Because of the scarcity of sediment:tissue BAF values for other vertebrate taxa in the published literature, a broad assumption was made concerning accumulation in these species. It was assumed that other vertebrate taxa evaluated in the food web model accumulate sediment contaminants to the same degree as do fish. Consequently, the BAFs derived from the fish tissue data were used to model uptake by other classes of vertebrate prey items.

This is a conservative estimate because it is unlikely that these other vertebrate prey items (amphibians, small birds, and small mammals) will accumulate chemicals in sediment to the same extent as fish, which may be exposed by ingestion of other aquatic organisms (e.g., aquatic invertebrates and small fish) as well as by dermal contact and ingestion of sediment. Amphibians, small birds, and small mammals are less frequently and less extensively exposed to sediments than are most fish in relatively shallow water bodies, and they are not in continuous contact with suspended sediments in surface water as are fish.

BAFs for Invertebrates and Plants. Limited literature values were available for plants and invertebrates; these values were used to estimate BAFs. If literature values were not available, conservative assumptions and extrapolative techniques were used to estimate BAFs. If an appropriate BAF could not be extrapolated, the BAF derived for fish was conservatively used.

Plant and invertebrate BAFs used for arsenic and cadmium were those used in the RI risk assessment (E&E 1993). Plant BAFs for several other metals were based on plant uptake factors for 5 leafy vegetables in MADEP (1992). The plant BAFs for DDT and its metabolites were based on BAFs for DDT obtained from the USEPA (1985) Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: DDT/DDE/DDD. The plant BAFs for other organic chemicals were calculated from the following equation from USEPA (1990) which relates bioaccumulation to an analyte's K_{ow} (octanol-water partitioning coefficient): $\log BAF = 1.588 - 0.578 \log K_{ow}$. This equation implicates high BAFs for highly water-soluble compounds, which is not supported by field studies which generally suggest that organic compounds with Kow's below 5 do not bioaccumulate in the food chain (Maughn 1993). Therefore, the BAFs for organic chemicals with a $\log K_{ow}$ value less than 5 were conservatively assumed to be 0.1.

An invertebrate BAF for PAHs was derived by averaging BAFs for several PAHs presented in Beyer (1990). This BAF was also used for bis(2-ethylhexyl) phthalate in the absence of more appropriate values for this chemical.

Table Q-2a
Bioaccumulation Factors for Various Ecological Receptors
Plow Shop Pond

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Analyte	Average Fish Tissue Concentration (mg/kg wet weight)	Average Sediment Concentration (mg/kg dry weight)	BAF [a,b,c]					
			plant	invertebrate	fish	amphibian/reptile	bird	mammal
Landfill Contaminants								
arsenic	0.185	997	0.21 [d]	0.105 [d]	0.00019	0.00019	0.00019	0.00019
barium	1.377	173	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080
nickel	ND (1/2SQL = 0.4)	38	3.2 [g]	0.011	0.011	0.011	0.011	0.011
manganese	26.3	1940	0.014	0.014	0.014	0.014	0.014	0.014
Other Parameters								
Organics								
4,4'-DDE	0.068	0.032	0.082 [e]	2.1	2.1	2.1	2.1	2.1
4,4'-DDD	0.0189	ND (1/2SQL = 0.05)	0.082 [e]	0.38	0.38	0.38	0.38	0.38
4,4'-DDT	0.0055	ND (1/2SQL = 0.008)	0.082 [e]	0.69	0.69	0.69	0.69	0.69
aroclor-1260	0.062	ND (1/2SQL = 0.27)	0.0029 [f]	0.23	0.23	0.23	0.23	0.23
benzo(a)anthracene	NA	0.223	0.01	0.01	0.01	0.01	0.01	0.01
chrysene	NA	0.323	0.01	0.01	0.01	0.01	0.01	0.01
fluoranthene	NA	0.502	0.01	0.01	0.01	0.01	0.01	0.01
naphthalene	NA	0.317	0.01	0.01	0.01	0.01	0.01	0.01
phenanthrene	NA	0.382	0.01	0.01	0.01	0.01	0.01	0.01
pyrene	NA	0.965	0.01	0.01	0.01	0.01	0.01	0.01
methylethylketone	NA	0.038	0.01	0.01	0.01	0.01	0.01	0.01
Inorganics								
aluminum	1.88	13104	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014
beryllium	ND (1/2SQL = 0.02)	1.12	0.018	0.018	0.018	0.018	0.018	0.018
cadmium	0.036	28.8	0.064 [d]	0.114 [d]	0.00125	0.00125	0.00125	0.00125
chromium	0.501	3246	0.00015	0.00015	0.00015	0.00015	0.00015	0.00015
cobalt	0.077	ND (1/2SQL = 0.71)	0.11	0.11	0.11	0.11	0.11	0.11
copper	0.613	62.7	0.01	0.01	0.01	0.01	0.01	0.01
lead	0.067	241	0.098	0.00028	0.00028	0.00028	0.00028	0.00028
mercury	0.678	28.6	0.024	0.024	0.024	0.024	0.024	0.024
selenium	0.4	ND (1/2SQL = 2.88)	0.14	0.14	0.14	0.14	0.14	0.14

Table Q-2a
Bioaccumulation Factors for Various Ecological Receptors
Plow Shop Pond

Remedial Investigation Addendum Report
Feasibility Study for Group 1A Sites
Fort Devens, MA

Analyte	Average Fish Tissue Concentration (mg/kg wet weight)	Average Sediment Concentration (mg/kg dry weight)	BAF [a,b,c]					
			plant	invertebrate	fish	amphibian/reptile	bird	mammal
thallium	0.053	ND (1/2SQL = 8.3)	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064
vanadium	ND (1/2SQL = 0.4)	62.6	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065
zinc	19.22	40.2	0.48	0.48	0.48	0.48	0.48	0.48

Notes:
[a] Fish BAF = fish tissue concentration/sediment concentration.
[b] Fish BAFs were used for other receptors when literature BAFs were unavailable.
When analyte undetected in fish, but detected in sediment, BAF = 0.5SQL fish/ sediment.
When analyte undetected in sediment, but detected in fish, BAF = fish/0.5 SQL sediment.
[c] BAFs for SVOCs were to be 0.01 when empirical data were unavailable.
[d] BAFs from E & E (1993).
[e] Arithmetic mean of values reported for various plant species in USEPA (1985).
[f] logBAF = 1.588 − 0.578logKOW (USEPA, 1990).
[g] Plant and small mammal value from USEPA (1985).
ND = Not Detected.
NA = Not Analyzed.
SQL = Sample Quantitation Limit.

Table Q-2b
Bioaccumulation Factors
Cold Spring Brook Pond

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Analyte	Average Fish Tissue Concentration (mg/kg wet weight)	Average Sediment Concentration (mg/kg dry weight)	BAF [a,b,c]					
			plant	invertebrate	fish	amphibian/reptile	bird	mammal
Organics								
4,4'-DDE	0.082	0.08	0.082 [d]	1.03	1.03	1.03	1.03	1.03
4,4'-DDD	0.124	0.42	0.082 [d]	0.29	0.29	0.29	0.29	0.29
aroclor-1254	0.028	ND (1/2SQL = 0.27) [f]	0.018 [e]	0.10	0.10	0.10	0.10	0.10
acenaphthylene	NA	0.54	0.01	0.01	0.01	0.01	0.01	0.01
anthracene	NA	0.57	0.01	0.01	0.01	0.01	0.01	0.01
bis(2-ethylhexyl)phthalate	NA	0.4	0.01	0.01	0.01	0.01	0.01	0.01
benzo(a)anthracene	NA	0.64	0.01	0.01	0.01	0.01	0.01	0.01
benzo(a)pyrene	NA	0.94	0.01	0.01	0.01	0.01	0.01	0.01
benzo(b)fluoranthene	NA	0.79	0.01	0.01	0.01	0.01	0.01	0.01
benzo(g,h,i)perylene	NA	0.22	0.01	0.01	0.01	0.01	0.01	0.01
benzo(k)fluoranthene	NA	1.47	0.01	0.01	0.01	0.01	0.01	0.01
chrysene	NA	1.19	0.01	0.01	0.01	0.01	0.01	0.01
fluoranthene	NA	1.96	0.01	0.01	0.01	0.01	0.01	0.01
indeno(1,2,3,c-d)pyrene	NA	0.32	0.01	0.01	0.01	0.01	0.01	0.01
phenanthrene	NA	0.85	0.01	0.01	0.01	0.01	0.01	0.01
pyrene	NA	2.74	0.01	0.01	0.01	0.01	0.01	0.01
methylethylketone	NA	0.007	0.01	0.01	0.01	0.01	0.01	0.01
Inorganics								
aluminum	ND (1/2SQL = 0.65)	8578	0.000076	0.000076	0.000076	0.000076	0.000076	0.000076
arsenic	0.104	49.8	0.21 [g]	0.105 [g]	0.0021	0.0021	0.0021	0.0021
barium	0.358	33.2	0.011	0.011	0.011	0.011	0.011	0.011
beryllium	ND (1/2SQL = 0.02)	0.11	0.18	0.18	0.18	0.18	0.18	0.18
chromium	0.248	14.6	0.017	0.017	0.017	0.017	0.017	0.017
cobalt	0.093	ND (1/2SQL = 0.71)	0.13	0.13	0.13	0.13	0.13	0.13
copper	0.507	10.8	0.05	0.05	0.05	0.05	0.05	0.05
lead	ND (1/2SQL = 0.05)	89.7	0.00056	0.00056	0.00056	0.00056	0.00056	0.00056
manganese	8.9	723.0	0.01	0.01	0.01	0.01	0.01	0.01

Table Q-2b
Bioaccumulation Factors
Cold Spring Brook Pond

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Feasibility Study for Group 1A Sites
Fort Devens, MA

Analyte	Average Fish Tissue Concentration (mg/kg wet weight)	Average Sediment Concentration (mg/kg dry weight)	BAF [a,b,c]					
			plant	invertebrate	fish	amphibian/reptile	bird	mammal
mercury	0.213	0.17	1.3	1.3	1.3	1.3	1.3	1.3
nickel	ND (1/2SQL = 0.4)	6.5	0.062	0.062	0.062	0.062	0.062	0.062
selenium	0.23	ND (1/2SQL = 2.88)	0.08	0.08	0.08	0.08	0.08	0.08
vanadium	ND (1/2SQL = 0.4)	18.7	0.021	0.021	0.021	0.021	0.021	0.021
zinc	26.6	114.6	0.23	0.23	0.23	0.23	0.23	0.23

Notes:

[a] Fish BAF = fish tissue concentration/sediment concentration.

[b] Fish BAFs were used for other receptors when literature BAFs were unavailable.
When analyte undetected in fish, but detected in sediment, BAF = 0.5SQL fish/ sediment.
When analyte undetected in sediment, but detected in fish, BAF = fish/0.5SQL sediment.

[c] BAFs for organics were estimated to be 0.01 when empirical data were unavailable.

[d] Arithmetic mean of values reported for various plant species in USEPA (1985).

[e] logBAF = 1.588 - 0.578logKOW (USEPA, 1990).

[f] SQL for aroclor-1260 used as surrogate.

[g] BAFs from E & E (1993).

ND = Not Detected.

NA = Not Analyzed.

SQL = Sample Quantitation Limit.

Table Q-3
Summary of Ingestion Toxicity Data for Terrestrial Wildlife (Reference Toxicity Values)

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Feasibility Study for Group 1A Sites
Fort Devens, MA

CHEMICAL	TEST SPECIES	TEST TYPE	DURATION	EFFECT	ACUTE* ORAL LD50 (mg/kgBW)	ACUTE* ACUTE ORAL RISK CRITERIA (mg/kgBW)	CHRONIC* LOAEL (mg/kgBW/day)	CHRONIC* NOAEL (mg/kgBW/day)	REFERENCE
SEMIVOLATILE ORGANICS									
Anthracene	Rodents	Oral (chronic)	NS	Carcinogenicity		33000 [b]	3300		Eisler, 1987
	Mouse	Oral (subchronic)	90 days	No effects				1000	IRIS, 1990
Benzo(a)anthracene	Rodents	Oral (chronic)	NS	Carcinogenicity		20 [b]	2		Eisler, 1987
Benzo(a)pyrene	Rat	Oral (subchronic)	Pregnancy	Sterility in offspring			40		USEPA, 1984
	Rodents	Oral (chronic)	NS	Carcinogenicity		0.02 [b]	0.002		Eisler, 1987
	Rat	Oral (chronic)	NS	Papillomas in stomach			2.5		USEPA, 1985
	Rat	Oral (subchronic)	Pregnancy	Decreased gonad weight			10		USEPA, 1984
	Rat	Oral (subchronic)	3.5 months	Reproductive effects			50		USEPA, 1984
	Rodents	Single oral dose		Mortality	50	10 [a]	1 [b]		Eisler, 1987
Benzo(b)fluoranthene	Rodents	Oral (chronic)	NS	Carcinogenicity		400 [b]	40		Eisler, 1987
Benzo(k)fluoranthene	Rodents	Oral (chronic)	NS	Carcinogenicity		720 [b]	72		Eisler, 1987
Bis(2-ethylhexyl)phthalate	Rat	Single oral dose		Mortality	8600	1720 [a]	172 [b]		NIOSH, 1985
	Guinea pig	Oral (chronic)	1 year	Increased liver weight			19		IRIS, 1992
	Rat	Single oral dose		Mortality	26000	5200 [a]	520 [b]		ATSDR, 1988
Dibenzofuran [f]	Rat	Oral (chronic)	103 week	Nephropathy			30		ATSDR, 1990
Fluoranthene	Rodents	Single oral dose		Mortality	2000	400 [a]	40 [b]		Eisler, 1987
	Mouse	Oral (subchronic)	90 days	Liver weight/physiological changes			250	125	IRIS, 1990
Naphthalene	Mouse	Single oral dose		Mortality	533	110 [a]			ATSDR, 1990
	Rat	Oral (subchronic)	13 weeks	Decreased body weight gain			35.7		USEPA, 1990
	Rat	Oral (chronic)	100 weeks	Ocular lesions			41		USEPA, 1990
	Rat	Oral (chronic)	700 days	NOAEL for death			205 [d]	41	ATSDR, 1990
Phenanthrene	Rodents	Single oral dose		Mortality	700	140 [a]	14 [b]		Eisler, 1987
	Rat	Oral (subchronic)	6 months	Increased liver weight			120		ATSDR, 1990
Pyrene	Mouse	Single oral dose		Mortality	800	160 [a]			NIOSH, 1985
	Mouse	Oral (subchronic)	13 weeks	Renal effects			125	75	IRIS, 1990
	Rat	Single oral dose		Mortality	2700	540 [a]			NIOSH, 1985
PESTICIDES/PCBs									
DDT	Mouse	Single oral dose		Mortality	200				USEPA, 1985
(surrogate for DDD,DDE)	Mouse	Oral (chronic)	24 month	Hepatocellular swelling and necrosis (males)			0.75	0.15	IRIS, 1991
	Rat	Single oral dose		Mortality	100	20 [a]	2 [b]		USEPA, 1985
	Rat	Oral (subchronic)	27 weeks	Kidney necrosis			10		ATSDR, 1988
	Rat	Oral (chronic)	2 year	Liver lesions		5 [b]	0.5		IRIS, 1991
	Rat	Oral (chronic)	3 generations	Reproductive effects			0.2		IRIS, 1991
	Chicken	Oral (subchronic)	10 weeks	Decreased reproductive success; toxic symptoms			91.4 [c]		USEPA, 1985

Table Q-3
Summary of Ingestion Toxicity Data for Terrestrial Wildlife (Reference Toxicity Values)

Remedial Investigation Addendum Report
Feasibility Study for Group 1A Sites
Fort Devens, MA

CHEMICAL	TEST SPECIES	TEST TYPE	DURATION	EFFECT	ACUTE* ORAL LD50 (mg/kgBW)	ACUTE* ACUTE ORAL RISK CRITERIA (mg/kgBW)	CHRONIC* LOAEL (mg/kgBW/day)	CHRONIC* NOAEL (mg/kgBW/day)	REFERENCE
	Rock dove	Single oral dose		Mortality	4000				USFWS, 1984
	Black duck	Oral (chronic)	2 years	Reduced eggshell thickness			0.14 [c]		Longcore and Stendell, 1977
	Mallard	Single oral dose		Mortality	2240				USFWS, 1984
	Mallard	Oral (chronic)	43–417 day	Mortality			7.2 [c]		USFWS, 1984
	Mallard	Oral (subchronic)	96 days	Reduced eggshell thickness			2.8 [c]		Longcore and Stendell, 1977
	California quail	Single oral dose		Mortality	595	119 [a]	12 [b]		USFWS, 1984
	Japanese quail	Single oral dose		Mortality	841				USFWS, 1984
	Pheasant	Single oral dose		Mortality	1334				USFWS, 1984
	Sandhill crane	Single oral dose		Mortality	1200	240 [a]	24 [b]		USFWS, 1984
	Kestrel	Oral (chronic)	7 wk – 1 year	Reduced eggshell thickness			0.56 [c]		USEPA, 1985
	Kestrel	Oral (chronic)	1 year	Reduced eggshell thickness			0.16 [c]		Wiemeyer, et al., 1986
	Barn Owl	Oral (chronic)	2 years	Reduced eggshell thickness		1.4 [b]	0.14 [c]		Longcore and Stendell, 1977
	Bullfrog	Single oral dose		Mortality	2000	400 [a]			USEPA, 1985
	Frog (Rana temporaria)	Oral (subchronic)	20 days	Mortality		76 [b]	7.6		Harri et al., 1979
	Dog	Single oral dose		Mortality	60	12 [a]	1.2 [b]		USEPA, 1985
	Dog	Oral (chronic)	3 generations	Premature puberty		50 [b]	5.0		ATSDR, 1988
Arodor 1254/1260	Rat	Single oral dose		Mortality	.500	100 [a]			Eisler, 1986
	Rat	Oral (chronic)	2 generations	Reduced litter size			7.6		USEPA 1985
	Rat	Oral (subchronic)	9 weeks	Fetal mortality/maternal toxicity			6.4		ATSDR, 1987
	Rat	Oral (chronic)	NS	Increase in F1 male liver weights			0.08		USEPA, 1976
	Chicken	Oral (chronic)	NS	Embryonic mortality			0.9 [c]		USEPA, 1976
	Rock dove	Oral (chronic)	NS	Parental incubation behavior		9.0 [b]	0.9 [c]		Peakall and Peakall, 1973
	Japanese quail	Oral (chronic)	NS	Reproduction unimpaired		50 [b]	5.0 [c]		Eisler, 1986
	American kestrel	Oral (subchronic)	69 days	Reduced sperm concentration		90 [b]	9		Eisler, 1986
	Mink	Single oral dose		Mortality	4000	800 [a]			Eisler, 1986
INORGANICS									
Aluminum	Mouse	Oral (chronic)	2–3 genrtns	Reduced body weight gain of newborns			425		NIOSH, 1985
	Rat	Oral (subchronic)	15 days	Reduced growth		1000 [b]	100		Bernuzzi, et al., 1989
Arsenic	Rat	Oral (chronic)	NS	Weight loss		75 [b]	7.5		USEPA, 1984
	Rat	Oral (subchronic)	90 days	No hematological, hepatic and renal effects			28.5 [d]	5.7	ATSDR, 1989
	Mallard	Single oral dose		Mortality	323	64.6 [a]	6.5 [b]		Eisler, 1988
	California quail	Single oral dose		Mortality	47.6	9.5 [a]	1.0 [b]		Eisler, 1988
	Pheasant	Single oral dose		Mortality	386	77.2 [a]	7.7 [b]		Eisler, 1988
	Dog	Oral (chronic)	NS	Mortality		2500 [b]	250 [d]	50	USEPA, 1984

Table Q-3
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Feasibility Study for Group 1A Sites
Fort Devens, MA

CHEMICAL	TEST SPECIES	TEST TYPE	DURATION	EFFECT	ACUTE* ORAL LD50 (mg/kgBW)	ACUTE* ACUTE ORAL RISK CRITERIA (mg/kgBW)	CHRONIC* LOAEL (mg/kgBW/day)	CHRONIC* NOAEL (mg/kgBW/day)	REFERENCE
Barium	Mouse	Oral (chronic)	lifetime	NOEL			4.13 [d]	0.825	IRIS, 1990
	Rat	Oral (chronic)	16 months	NOEL			25.5 [d]	5.1	IRIS, 1990
	Rat	Oral (chronic)	lifetime	NOEL		10 [b]	1 [d]	0.25	IRIS, 1990
	Rat	Oral (subchronic)	13 weeks	NOEL			157.5 [d]	31.5	IRIS, 1990
Beryllium	Rat	Single oral dose		Mortality	10	2.0 [a]			USEPA, 1985
	Rat	Oral (chronic)	3.2 years	No respiratory, hepatic, renal, or cardiovascular effects			4.25 [d]	0.85	ATSDR, 1989
	Rat	Oral (chronic)	NS	Increase in lung sarcomas			0.22		USEPA, 1985
Cadmium	Mouse	Oral (chronic)	18 months	Histopathological effects		18 [b]	1.75		ATSDR, 1988
	Mouse	Oral (subchronic)	28 days	Alteration in blood chemistry			0.32		Eisler, 1985
	Mouse (young)	Oral (subchronic)	28 days	Blood chemistry altered				1.8	Eisler, 1985
	Rat	Single oral dose		Mortality	250	50 [a]			Eisler, 1985
	Rat	Single oral dose		Testicular damage				100	Eisler, 1985
	Rat	Oral (subchronic)	12 weeks	Hepatic and Renal necrosis			14		ATSDR, 1992
	Guinea pig	Single oral dose		Mortality	150	30 [a]	3 [b]		Eisler, 1985
	Japanese quail	Oral (subchronic)	6 weeks	Bone marrow hypoplasia		76 [b]	7.6		Eisler, 1985
	Dog	Oral (subchronic)	3 months	NOAEL			3.75 [d]	0.75	
Chromium	Mouse	Oral (subchronic)	13 weeks	Testicular degeneration		57 [b]	5.7		ATSDR, 1991
(Cr+3)	Mouse	Oral (subchronic)	19 days	Fetal resorptions, gross anomalies			57		ATSDR, 1989
	Rat	Oral (subchronic)	28 days	Renal and neurological deficits			98		ATSDR, 1989
	Rabbit	Oral (subchronic)	6 weeks	Liver and blood chemistry effects		17 [b]	1.7		Eisler, 1986
(Cr+6)	Chicken	Oral (subchronic)	32 days	Growth, survival				8	Eisler, 1986
(Cr+6)	Black duck	Oral (subchronic)	5 months	Growth patterns altered			3.5		Eisler, 1986
(Potassium dichromate)	Japanese quail	Oral (acute)	5 days	Mortality	126 [c]	25 [a]	2.5 [b]		Hill and Camardese, 1986
Cobalt	Rat	Single oral dose		Mortality	91	18 [a]	1.8 [b]		ATSDR, 1991
	Rat	Single oral dose		Hepatic/renal hyperemia		157.3			ATSDR, 1991
	Rat	Oral (subchronic)	8 weeks	Decreased body weight gain			4.2		ATSDR, 1991
	Rat	Oral (acute)	1 week	Stunted growth during gestation			0.0 [b]		ATSDR, 1991
	Rat	Oral (subchronic)	98 days	Testicular degeneration			13.25		ATSDR, 1991
	Rat	Oral (subchronic)	69 days	Testicular atrophy			20		ATSDR, 1991
	Guinea pig	Oral (subchronic)	5 week	Mortality		20			ATSDR, 1991
	Dog	Oral (subchronic)	4 weeks	Increased red blood cell count		50 [b]	5		ATSDR, 1991
Copper	Rat	Single oral dose		TDlo for reproductive effects		152	15.2 [b]		NIOSH, 1985
	Rat	Oral (subchronic)	22 weeks	Fetotoxicity; CNS abnormalities			152		NIOSH, 1985
	Rat	Oral (subchronic)	35 weeks	Pre-implantation mortality		12 [b]	1.21		NIOSH, 1985
	Swine	Oral (subchronic)	9 months	Mortality			1.4		USEPA, 1980

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CHEMICAL	TEST SPECIES	TEST TYPE	DURATION	EFFECT	ACUTE* ORAL LD50 (mg/kgBW)	ACUTE* ACUTE ORAL RISK CRITERIA (mg/kgBW)	CHRONIC* LOAEL (mg/kgBW/day)	CHRONIC* NOAEL (mg/kgBW/day)	REFERENCE
	Mallard	Oral (subchronic)	29 days	No effect on survivorship		2.09	0.2 [b]		Demayo et al., 1982
	Mallard	Oral (subchronic)	NS	LOAEL			29		NRC, 1977
Iron	Rat	Oral (subchronic)	12 weeks	Slight liver injury			2400		Britton et al, 1990
Lead	Mouse	Oral (subchronic)	NS	Reduced sucess of implanted ova			1.5		Eisler, 1988
	Rat	Single oral dose		Mortality	12	2 [a]			Eisler, 1988
	Rat	Single oral dose		LDLO	17	3 [a]	0.3 [b]		Eisler, 1988
	Rat	Oral (subchronic)	Days 12-14 (preg)	Increased fetal resorption rate; decreased fetal BW		2.5	0.3 [b]		McClain and Becker, 1972
	Rat	Oral (subchronic)	Days 5-15 (preg)	Increased resorptions/dam		1	0.1 [b]		Kennedy et al., 1975
	Rat	Oral (subchronic)	3 weeks	Increased locomotor activity		1.5 [c]	0.2 [b]		Eisler, 1988
	Rat	Oral (chronic)	2 years	Decreased ALAD synthesis			2.16 [c]		ATSDR, 1988
	Rat	Oral (subchronic)	3 weeks	Increased locomotor activity			25		Eisler, 1988
	Rabbit	Single oral dose		LDLO	24	5 [a]	0.5 [b]		ATSDR, 1988
	Rabbit	Oral (chronic)	NS	Mortality		5.1 [b]	0.51 [c]		USEPA, 1988
	Chicken	Oral (subchronic)	4 weeks	Growth rate suppressed			169 [c]		Eisler, 1988
	Ringed turtle-dove	Oral (acute)	NS	Some mortality; kidney damage	75	15 [a]			Eisler, 1988
	Mallard	Single oral dose		Mortality	107	21 [a]	2.1 [b]		Eisler, 1988
	Mallard	Oral (subchronic)	NS	Some mortality and ALAD decrease	151	30 [a]	3.0 [b]		Eisler, 1988
	Mallard	Oral (subchronic)	12 weeks	Decrease in ALAD activity			1.75 [c]		Eisler, 1988
	Japanese quail	Single oral dose		Mortality	24.6	4.9 [a]			Eisler, 1988
	Starling	Oral (acute)	11 days	Reduced food consumption			2.8		Eisler, 1988
	Kestrel (nestlings)	Oral (acute)	10 days	Abnormal development		125	12.5 [b]		Eisler, 1988
	Kestrel (nestlings)	Oral (acute)	10 days	ALAD depression		25	2.5 [b]		Eisler, 1988
	Kestrel (nestlings)	Oral (acute)	10 days	Mortality and developmental effects		625	62.5 [b]		Eisler, 1988
	Kestrel	Oral (subchronic)	5 months	NOEL			4.45 [d]	0.89 [c]	Eisler, 1988
	Kestrel	Oral (subchronic)	5 months	Blood ALAD reduced 80%		44 [b]	4.4 [c]		Eisler, 1988
	Cattle (calves)	Oral (subchronic)	105 days	Mortality		60 [b]	6		Eisler, 1988
	Horse	Oral (chronic)	NS	Mortality			2.4		Eisler, 1988
	Dog	Oral (acute)	NS	LDLO		300	30 [b]		ATSDR, 1988
	Dog	Oral (subchronic)	180 days	Anorexia and convulsions		30 [b]	3		Eisler, 1988
Manganese	Mouse	Oral (subchronic)	6 months	Mortality				2300	ATSDR, 1990
	Mouse	Oral (subchronic)	90 days	Delayed growth of testes			140		ATSDR, 1990
	Mouse	Oral (chronic)	103 weeks	Mortality			4050 [d]	810	ATSDR, 1990
	Rat	Single oral dose		Mortality	410				ATSDR, 1990
	Rat	Oral (subchronic)	20 day	Mortality	225	45 [a]	4.5 [b]		ATSDR, 1990
	Rat	Oral (subchronic)	10 weeks	Hepatic effects			60 [d]	12	ATSDR, 1990

Table Q-3
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Fort Devens, MA

CHEMICAL	TEST SPECIES	TEST TYPE	DURATION	EFFECT	ACUTE* ORAL LD50 (mg/kgBW)	ACUTE* ACUTE ORAL RISK CRITERIA (mg/kgBW)	CHRONIC* LOAEL (mg/kgBW/day)	CHRONIC* NOAEL (mg/kgBW/day)	REFERENCE
	Rat	Oral (subchronic)	20 days	Decreased litter weight during gestation		1240		620	ATSDR, 1990
	Rat	Oral (chronic)	103 weeks	Mortality			930		ATSDR, 1990
	Rat	Oral (subchronic)	2 months	Biochemical alterations in CNS			600		ATSDR, 1990
	Guinea pig	Single oral dose		Mortality	400				USEPA, 1984
	Monkey	Oral (chronic)	18 months	Weakness, rigidity			25		ATSDR, 1990
Mercury	Mouse	Single oral dose		Mortality	22				NIOSH, 1985
	Mouse	Oral (subchronic)	18 days	Mortality; neurological symptoms			6.3		Suzuki, 1979
	Mouse	Oral (subchronic)	38 days	Mortality; neurological symptoms			5		Suzuki, 1979
	Mouse	Oral (subchronic)	50 days	Embryotoxicity and teratogenicity			0.9		Suzuki, 1979
	Mouse	Oral (subchronic)	45 days	Hypophagia, weight loss, weakness of hind legs			1		Suzuki, 1979
	Mouse	Oral (subchronic)	Day 6-17 (gest)	Stillbirths and neonatal death			4		Suzuki, 1979
	Mouse	Oral (subchronic)	Day 0-18 (gest)	Embryolethality and teratogenicity			0.7		Suzuki, 1979
	Rat	Oral (subchronic)	Day 6-14 (gest)	Retarded fetus growth and teratogenicity			4		Suzuki, 1979
	Rat	Oral (subchronic)	Gest.+ 16 days	Behavioral changes in offspring			0.12 [c]		Suzuki, 1979
	Rat	Oral (chronic)	NS	Reduced fertility			0.5		Eisler, 1987
	Rat	Oral (subchronic)	38 days	Adverse behavioral change			0.16 [c]		Eisler, 1987
	Rat	Single oral dose		Mortality	18	3.6 [a]	0.36 [b]		NIOSH, 1985
	Pig	Oral (chronic)	Pregnancy	High incidence of stillbirths			0.5		Eisler, 1987
	House sparrow	Single oral dose		Mortality	12.6	2.5 [a]			Eisler, 1987
	Rock dove	Single oral dose		Mortality	22.8	4.6 [a]			Eisler, 1987
	Pigeon	Oral (subchronic)	17 days	Behavioral alterations			3		Eisler, 1987
	Pigeon	Oral (subchronic)	5 weeks	Behavioral alterations			1		Eisler, 1987
	Starling	Oral (subchronic)	8 weeks	Kidney lesions			0.25 [c]		Eisler, 1987
	Chicken	Single oral dose		Mortality	20	4 [a]			Fimreite, 1979
	Bantam chicken	Single oral dose		Mortality	190	38 [a]			Fimreite, 1979
	Prairie chicken	Single oral dose		Mortality	11.5	2 [a]	0.2 [b]		Eisler, 1987
	Chukar	Single oral dose		Mortality	26.9	5 [a]			Eisler, 1987
	Coturnix	Single oral dose		Mortality	11	2 [a]			Eisler, 1987
	Mallard	Single oral dose		Mortality	2.2	0.4 [a]			Eisler, 1987
	Black duck	Oral (subchronic)	28 weeks	Reproduction inhibited, brain lesions			0.22 [c]		Eisler, 1987
	Fulvous whistling duck	Single oral dose		Mortality	37.8	7.6 [a]			Eisler, 1987
	Northern bobwhite	Single oral dose		Mortality	23.8	4.8 [a]			Eisler, 1987
	Bobwhite quail	Oral (acute)	5 days	Mortality	523	105 [a]			Hill et al., 1975
	Japanese quail	Single oral dose		Mortality	14.4	2.9 [a]			Eisler, 1987

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	Japanese quail	Oral (subchronic)	3 weeks	Depressed gonad weights			0.81 [c]		Eisler, 1987
	Japanese quail	Oral (subchronic)	9 weeks	Alterations in brain and plasma enzyme activities			0.10 [c]		Eisler, 1987
	Japanese quail	Oral (subchronic)	NS	Reproductive effects			5.0 [c]		Fimreite, 1979
	Gray partridge	Single oral dose		Mortality	17.6	3.5 [a]			Eisler, 1987
	Gray pheasant	Oral (subchronic)	30 days	Reduced reproductive ability			0.64		Eisler, 1987
	Ring-necked pheasant	Single oral dose		Mortality	11.5	2.3 [a]			Eisler, 1987
	Mule deer	Single oral dose		Mortality	17.9	3.6 [a]	0.36		Eisler, 1987
	Rhesus monkey	Oral (chronic)	Pregnancy	Maternally toxic and abortient			0.5		Eisler, 1987
	River otter	Single oral dose		Mortality	2	0.4 [a]			Eisler, 1987
	Mink	Single oral dose		Mortality	1	0.2 [a]			Eisler, 1987
	Mink	Oral (subchronic)	2 months	Mortality			0.029 [c]		Eisler, 1987
	Mink	Oral (subchronic)	37 days	Mortality			0.14 [c]		Eisler, 1987
	Cat	Oral (subchronic)	Day 10-58 (gest)	Increased incidence of anomalous fetuses			0.25		Eisler, 1987
	Dog	Oral (chronic)	Pregnancy	High incidence of stillbirths		1 [b]	0.1		Eisler, 1987
Nickel	Rat	Single oral dose		Mortality	67	13.4 [a]	1.3 [b]		ATSDR, 1987
	Rat	Oral (subchronic)	91 days	Mortality			25 [d]	5	ATSDR, 1987
	Rat	Oral (chronic)	2 years	Decreased body weight gain			50	5	ATSDR, 1987
	Japanese quail	Oral (acute)	5 days	NOEL	504 [c]	100.7 [a]	10.1 [b]		Hill and Camardese, 1986
	Dog	Oral (chronic)	2 years	Histologic lesions in bone marrow		625 [b]	62.5	25	ATSDR, 1987
Selenium	Rat	Oral (chronic)	NS	Selenosis		0.04 [c]	0.004 [b]		Eisler, 1985
	Rat	Oral (chronic)	NS	Histological changes in heart and kidney			0.045		Eisler, 1985
	Rat	Oral (chronic)	2 years	Soft bones, hepatic lesions			0.2		ATSDR, 1989
	Japanese quail	Oral (chronic)	NS	Reduced egg hatching		0.6 [c]	0.06 [b]		Eisler, 1985
	Mallard	Oral (subchronic)	3 months	Reduced hatchability			1.75		Eisler, 1985
	Horse	Single oral dose		MLD	3.3				Eisler, 1985
Silver	Rat	Oral (subchronic)	125 day	Hypoactivity			18.1		ATSDR, 1989
Thallium	Rat	Oral (subchronic)	90 days	Incidence of alopecia; blood chemistry changes			1		IRIS, 1989
	Rat	Oral (subchronic)	240 days	Histopathological changes			1.4		IRIS, 1989
Vanadium	Rat	Oral (chronic)	2.5 years	Decreased hair cystine			4 [d]	0.89	IRIS, 1989
	Rat	Oral (subchronic)	103 days	Decreased hair cystine, hemoglobin		25 [b]	2.5		IRIS, 1989
	Rat	Oral (subchronic)	75-103 days	NOAEL for hematological alterations			33 [d]	6.6	ATSDR, 1991
	Japanese quail	Oral (acute)	5 days	Mortality	96 [c]	20 [a]	2 [b]		Hill and Camardese, 1986

Table Q-3

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Fort Devens, MA

CHEMICAL	TEST SPECIES	TEST TYPE	DURATION	EFFECT	ACUTE* ORAL LD50 (mg/kgBW)	ACUTE* ACUTE ORAL RISK CRITERIA (mg/kgBW)	CHRONIC* LOAEL (mg/kgBW/day)	CHRONIC* NOAEL (mg/kgBW/day)	REFERENCE
Zinc	Rat	Single oral dose		Mortality	2510	500 [a]			Sax, 1984
	Rat	Oral (subchronic)	NS	Kidney toxicity			160		Llobet, et al., 1988

[a] For chemicals lacking LOAEL or NOAEL data, an Acute Oral Criterion (AOC) is calculated by applying a factor of 0.2 to the acute LD50; this value is expected to protect 99.9% of the exposed population from acute effects (USEPA, 1986).
[b] Estimated by applying an acute-chronic ratio of 10.
[c] Converted to dose per kilogram body weight by multiplying by ingestion rate and dividing by body weight.
The following ingestion rate and body weight data were used:

Species	Ingestion Rate (kg/day)	Body Weight (kg)	Reference
Rat (Male)	0.025	0.58	USEPA, 1988
Rat (Female)	0.02	0.25	USEPA, 1988
Rat	0.015	0.25	NIOSH, 1985
Rabbit	0.059	2.2	USEPA, 1988
Chicken	0.106	1.16	USEPA, 1988
Bobwhite	0.015	0.17	Kenaga, 1973
California quail	0.014 [e]	0.139	USEPA, 1988
Mallard Duck	0.09	1.25	Terres, 1980
Duck	0.112 [e]	1.6	USEPA, 1988
Starling	0.01	0.0437	USEPA, 1988
Kestrel	0.01	0.179	USEPA, 1988
Screech Owl	0.0086	0.169	USEPA, 1988
Mink	0.0465	1.613	USEPA, 1988
Mouse	0.0035	0.03	USEPA, 1988
Dog	0.5	14.47	USEPA, 1988

[d] Estimated by applying a LOAEL-NOAEL ratio of 5 (Newell, et al., 1987).
[e] Ingestion rate estimated from body weight using allometric equation for chickens in USEPA, 1988.
[f] Data not available for dibenzofuran; 2,3-benzofuran used as surrogate.
[g] Diet contained 3% iron carbonyl. Converted to dose per kg body weight using a male rat ingestion rate shown above and a study-specific rat weight of 0.1 kg. Resulting dose (in FeCO4) was multiplied by 32% (Fe comprises 32% of FeCO4) to arrive at Fe dose.
BW = Body Weight
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level

Table Q-4
Reference Toxicity Values Selected for Group 1A Sites

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Feasibility Study for Group 1A Sites
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Analyte	Ecological Receptor							
	Muskrat	Mallard duck	Green frog	Painted turtle	Mink	Raccoon	Osprey	Great blue heron
	Reference Toxicity Values (mg/kg body weight/day)							
Organics								
anthracene	3300	3300	3300	3300	3300	3300	3300	3300
benzo(a)anthracene	2	2	2	2	2	2	2	2
benzo(a)pyrene	1.25 [c]	1.25 [c]	1.25 [c]	1.25 [c]	1.25 [c]	1.25 [c]	1.25 [c]	1.25 [c]
benzo(b)fluoranthene	40	40	40	40	40	40	40	40
benzo(k)fluoranthene	72	72	72	72	72	72	72	72
bis(2-ethylhexyl)phthalate	19	19	19	19	19	19	19	19
chrysene	99	99	99	99	99	99	99	99
dibenzofuran	30	30	30	30	30	30	30	30
fluoranthene	250	250	250	250	250	250	250	250
naphthalene	41	41	41	41	41	41	41	41
phenanthrene	120	120	120	120	120	120	120	120
pyrene	125	125	125	125	125	125	125	125
Pesticides/PCBs								
DDD	0.48 [c]	0.14	7.6	7.6	5	5	0.29 [d]	0.25 [b]
DDE	0.48 [c]	0.14	7.6	7.6	5	5	0.29 [d]	0.25 [b]
DDT	0.48 [c]	0.14	7.6	7.6	5	5	0.29 [d]	0.25 [b]
aroclor-1254	3.84 [c]	2.3 [b]	2.3 [b]	2.3 [b]	3.84 [c]	3.84 [c]	9	2.3 [b]
aroclor-1260	3.84 [c]	2.3 [b]	2.3 [b]	2.3 [b]	3.84 [c]	3.84 [c]	9	2.3 [b]
Inorganics								
aluminum	425	425	425	425	425	425	425	425
arsenic	7.5	6.5	5.1 [b]	5.1 [b]	250	250	5.1 [b]	5.1 [b]
barium	10.2 [c]	10.2 [c]	10.2 [c]	10.2 [c]	10.2 [c]	10.2 [c]	10.2 [c]	10.2 [c]
beryllium	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
cadmium	1.75	7.6	7.6	7.6	3.75	3.75	7.6	7.6
chromium	40.6 [c]	3.5	3.5	3.5	40.6 [c]	40.6 [c]	3.5	3.5
cobalt	12.5 [c]	12.5 [c]	12.5 [c]	12.5 [c]	5	5	12.5 [c]	12.5 [c]
copper	76.6 [c]	29	29	29	76.6 [c]	76.6 [c]	29	29
iron	2400	2400	2400	2400	2400	2400	2400	2400
lead	2.1	1.75	4.4	4.4	3	3	4.4	4.4
manganese	370 [c]	370 [c]	370 [c]	370 [c]	25	25	370 [c]	370 [c]
mercury	0.5	0.22	0.86 [b]	0.86 [b]	0.09 [c]	0.1	0.1 [e]	0.1 [e]
nickel	50	10.1	10.1	10.1	62.5	62.5	10.1	10.1
selenium	0.12 [c]	1.75	1.75	1.75	0.12 [c]	0.12 [c]	1.75	1.75
silver	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
thallium	1.2 [c]	1.2 [c]	1.2 [c]	1.2 [c]	1.2 [c]	1.2 [c]	1.2 [c]	1.2 [c]
vanadium	2.5	2	2	2	2.5	2.5	2	2
zinc	160	160	160	160	160	160	160	160

[a] All values are chronic Lowest Observed Adverse Effects Levels (LOAELs), unless otherwise noted.
Values were obtained from the master Reference Toxicty Values (RTVs) summary table (Q-3)
[b] Average of LOAEL bird values (see Section 7.1.3.4).
[c] Average of LOAEL values (see Section 7.1.3.4).
[d] Average of kestrel and barn owl values.
[e] The lowest bird LOAEL value was used as a conservative measure to protect fish-ingesting bird species.

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ECOLOGICAL RISK ASSESSMENT SPREADSHEETS

SHEPLEY'S HILL LANDFILL/COLD SPRING BROOK POND

TABLE R-1

ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE CONCENTRATION DATA

CHEMICAL	AVERAGE CONCENTRATION (mg/kg)
arsenic	4.7E+02
barium	1.1E+02
manganese	2.6E+03
nickel	2.3E+01
iron	3.6E+04

ESTIMATED TISSUE LEVELS IN PRIMARY PREY ITEMS

Invert BAF [a]	Tissue Level (mg/kg)	Plant BAF [a]	Tissue Level (mg/kg)
1.1E-01	4.9E+01	2.1E-01	9.8E+01
1.3E-02	1.4E+00	1.3E-02	1.4E+00
1.0E-02	2.6E+01	1.0E-02	2.6E+01
1.7E-02	3.9E-01	9.0E-02	2.1E+00
1.2E-03	4.4E+01	1.2E-03	4.4E+01

BAF VALUES FOR OTHER PREY ITEMS

Small Mammal BAF [a]	Small Bird BAF [a]	Reptile/ Amphib. BAF [a]	Fish BAF [a]
4.0E-04	4.0E-04	4.0E-04	4.0E-04
1.3E-02	1.3E-02	1.3E-02	1.3E-02
1.0E-02	1.0E-02	1.0E-02	1.0E-02
1.7E-02	1.7E-02	1.7E-02	1.7E-02
1.2E-03	1.2E-03	1.2E-03	1.2E-03

SITE AREA:	30 acres

TABLE R-1
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW–day) [b]

CHEMICAL	*Great Blue Heron*	*Mallard*	*Painted Turtle*	*Green Frog*	*Osprey*
arsenic	2.98E–01	3.66E+00	4.17E+00	5.90E+00	2.03E–04
barium	6.40E–02	1.29E–01	3.39E–01	4.66E–01	1.52E–03
manganese	1.49E+00	2.87E+00	7.91E+00	1.06E+01	2.86E–02
nickel	1.45E–02	8.42E–02	1.10E–01	1.25E–01	4.24E–04
iron	1.77E+01	2.81E+01	9.35E+01	1.15E+02	4.73E–02

TABLE R-1
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Muskrat*	*Mink*	*Raccoon*
arsenic	5.33E+00	1.29E+00	4.82E-02
barium	2.44E-01	2.51E-01	4.97E-03
manganese	5.37E+00	5.53E+00	1.12E-01
nickel	1.32E-01	5.73E-02	1.48E-03
iron	5.83E+01	6.01E+01	1.34E+00

TABLE R-1
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION - LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Invert	Plant	Smal Mammal	Herpeto-fauna	Bird	Sediment	Fist	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Great Blue Heron	(Pred. Bird)	16%	0%	5%	4%	0%	5%	70%	100	0.5	1.5E-01	0.187	2.95
Mallard	(Waterfowl)	11%	87%	0%	0%	0%	2%	0%	30	0.5	5.0E-01	0.086	1.177
Painted Turtle	(Reptile)	43%	39%	0%	0%	0%	5%	13%	12	0.75	7.5E-01	0.056	0.834
Green Frog	(Amphibian)	70%	10%	0%	7%	0%	3%	10%	0.5	0.75	7.5E-01	0.005	0.037
Osprey	(Pred. Bird)	0%	0%	0%	0%	0%	0%	100%	100	0.05	1.5E-02	0.094	1.3

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-1

ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Muskrat	(Small Mammal)	5%	87%	0%	0%	0%	3%	5%	26	1	1.0E+00	0.065	1.25
Mink	(Pred. Mammal)	20%	0%	25%	0%	0%	3%	52%	35	1	8.6E-01	0.050	0.8
Raccoon	(Pred. Mammal)	25%	31%	9%	20%	1%	5%	9%	1150	1	2.6E-02	0.221	7.95

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R–2
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	***Great Blue Heron***			***Mallard***			***Painted Turtle***		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
arsenic	3.0E–01	5.1E+00	5.8E–02	3.7E+00	6.5E+00	5.6E–01	4.2E+00	5.1E+00	8.2E–01
barium	6.4E–02	1.0E+01	6.3E–03	1.3E–01	1.0E+01	1.3E–02	3.4E–01	1.0E+01	3.3E–02
manganese	1.5E+00	3.7E+02	4.0E–03	2.9E+00	3.7E+02	7.8E–03	7.9E+00	3.7E+02	2.1E–02
nickel	1.4E–02	1.0E+01	1.4E–03	8.4E–02	1.0E+01	8.3E–03	1.1E–01	1.0E+01	1.1E–02
iron	1.8E+01	2.4E+03	7.4E–03	2.8E+01	2.4E+03	1.2E–02	9.4E+01	2.4E+03	3.9E–02
SUMMARY HAZARD INDEX			**7.8E–02**			**6.0E–01**			**9.2E–01**

TABLE R-2
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION - LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

CHEMICAL	Muskrat			Raccoon			Mink		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
arsenic	5.3E+00	7.5E+00	7.1E-01	4.8E-02	2.5E+02	1.9E-04	1.3E+00	2.5E+02	5.2E-03
barium	2.4E-01	1.0E+01	2.4E-02	5.0E-03	1.0E+01	4.9E-04	2.5E-01	1.0E+01	2.5E-02
manganese	5.4E+00	3.7E+02	1.5E-02	1.1E-01	2.5E+01	4.5E-03	5.5E+00	2.5E+01	2.2E-01
nickel	1.3E-01	5.0E+01	2.6E-03	1.5E-03	6.3E+01	2.4E-05	5.7E-02	6.3E+01	9.2E-04
iron	5.8E+01	2.4E+03	2.4E-02	1.3E+00	2.4E+03	5.6E-04	6.0E+01	2.4E+03	2.5E-02
SUMMARY HAZARD INDEX			**7.8E-01**			**5.7E-03**			**2.8E-01**

NOTES: TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-2
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION - LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

CHEMICAL	Green Frog			Osprey		
	TBD	RTV	HQ	TBD	RTV	HQ
arsenic	5.9E+00	5.1E+00	1.2E+00	2.0E-04	5.1E+00	4.0E-05
barium	4.7E-01	1.0E+01	4.6E-02	1.5E-03	1.0E+01	1.5E-04
manganese	1.1E+01	3.7E+02	2.9E-02	2.9E-02	3.7E+02	7.7E-05
nickel	1.3E-01	1.0E+01	1.2E-02	4.2E-04	1.0E+01	4.2E-05
iron	1.1E+02	2.4E+03	4.8E-02	4.7E-02	2.4E+03	2.0E-05
SUMMARY HAZARD INDEX			**1.3E+00**			**3.3E-04**

NOTES:

TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-3

ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE CONCENTRATION DATA

CHEMICAL	MAXIMUM CONCENTRATION (mg/kg)
arsenic	3.2E+03
barium	3.4E+02
manganese	5.5E+04
nickel	7.9E+01
iron	3.3E+05

ESTIMATED TISSUE LEVELS IN PRIMARY PREY ITEMS

Invert BAF [a]	Tissue Level (mg/kg)	Plant BAF [a]	Tissue Level (mg/kg)
1.1E-01	3.4E+02	2.1E-01	6.7E+02
1.3E-02	4.5E+00	1.3E-02	4.5E+00
1.0E-02	5.5E+02	1.0E-02	5.5E+02
1.7E-02	1.3E+00	9.0E-02	7.1E+00
1.2E-03	4.0E+02	1.2E-03	4.0E+02

BAF VALUES FOR OTHER PREY ITEMS

Small Mammal BAF [a]	Small Bird BAF [a]	Reptile/ Amphib. BAF [a]	Fish BAF [a]
4.0E-04	4.0E-04	4.0E-04	4.0E-04
1.3E-02	1.3E-02	1.3E-02	1.3E-02
1.0E-02	1.0E-02	1.0E-02	1.0E-02
1.7E-02	1.7E-02	1.7E-02	1.7E-02
1.2E-03	1.2E-03	1.2E-03	1.2E-03

SITE AREA:	30 acres

TABLE R-3
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Great Blue Heron*	*Mallard*	*Painted Turtle*	*Green Frog*	*Osprey*
arsenic	2.04E+00	2.50E+01	2.85E+01	4.04E+01	1.39E-03
barium	2.04E-01	4.11E-01	1.08E+00	1.49E+00	4.85E-03
manganese	3.10E+01	5.97E+01	1.64E+02	2.20E+02	5.94E-01
nickel	4.99E-02	2.90E-01	3.78E-01	4.32E-01	1.46E-03
iron	1.60E+02	2.55E+02	8.50E+02	1.04E+03	4.30E-01

TABLE R-3
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Muskrat*	*Mink*	*Raccoon*
arsenic	3.63E+01	8.80E+00	3.28E-01
barium	7.62E-01	7.85E-01	1.56E-02
manganese	1.13E+02	1.17E+02	2.36E+00
nickel	4.54E-01	1.97E-01	5.11E-03
iron	5.35E+02	5.51E+02	1.22E+01

TABLE R-3
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION - LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Great Blue Heron	(Pred. Bird)	16%	0%	5%	4%	0%	5%	70%	100	0.5	1.5E-01	0.187	2.95
Mallard	(Waterfowl)	11%	87%	0%	0%	0%	2%	0%	30	0.5	5.0E-01	0.086	1.177
Painted Turtle	(Reptile)	43%	39%	0%	0%	0%	5%	13%	12	0.75	7.5E-01	0.056	0.834
Green Frog	(Amphibian)	70%	10%	0%	7%	0%	3%	10%	0.5	0.75	7.5E-01	0.005	0.037
Osprey	(Pred. Bird)	0%	0%	0%	0%	0%	0%	100%	100	0.05	1.5E-02	0.094	1.3

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-3
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Muskrat	(Small Mammal)	5%	87%	0%	0%	0%	3%	5%	26	1	1.0E+00	0.065	1.25
Raccoon	(Pred. Mammal)	25%	31%	9%	20%	1%	5%	9%	1150	1	2.6E-02	0.221	7.95
Mink	(Pred. Mammal)	20%	0%	25%	0%	0%	3%	52%	35	1	8.6E-01	0.05	0.8

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[e] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-4
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION - LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

CHEMICAL	*Great Blue Heron*			*Mallard*			*Painted Turtle*		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
arsenic	2.0E+00	5.1E+00	4.0E-01	2.5E+01	6.5E+00	3.9E+00	2.9E+01	5.1E+00	5.6E+00
barium	2.0E-01	1.0E+01	2.0E-02	4.1E-01	1.0E+01	4.0E-02	1.1E+00	1.0E+01	1.1E-01
manganese	3.1E+01	3.7E+02	8.4E-02	6.0E+01	3.7E+02	1.6E-01	1.6E+02	3.7E+02	4.4E-01
nickel	5.0E-02	1.0E+01	4.9E-03	2.9E-01	1.0E+01	2.9E-02	3.8E-01	1.0E+01	3.7E-02
iron	1.6E+02	2.4E+03	6.7E-02	2.6E+02	2.4E+03	1.1E-01	8.5E+02	2.4E+03	3.5E-01
SUMMARY HAZARD INDEX			**5.8E-01**			**4.2E+00**			**6.5E+00**

TABLE R-4
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	Muskrat			Raccoon			Mink		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
arsenic	3.6E+01	7.5E+00	4.8E+00	3.3E−01	2.5E+02	1.3E−03	8.8E+00	2.5E+02	3.5E−02
barium	7.6E−01	1.0E+01	7.5E−02	1.6E−02	1.0E+01	1.5E−03	7.9E−01	1.0E+01	7.7E−02
manganese	1.1E+02	3.7E+02	3.1E−01	2.4E+00	2.5E+01	9.5E−02	1.2E+02	2.5E+01	4.7E+00
nickel	4.5E−01	5.0E+01	9.1E−03	5.1E−03	6.3E+01	8.2E−05	2.0E−01	6.3E+01	3.2E−03
iron	5.3E+02	2.4E+03	2.2E−01	1.2E+01	2.4E+03	5.1E−03	5.5E+02	2.4E+03	2.3E−01
SUMMARY HAZARD INDEX			5.4E+00			1.0E−01			5.0E+00

NOTES:
TBD = Total Body Dose (mg/kgBW−day)
RTV = Reference Toxicity Value (mg/kgBW−day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R–4
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION – LANDFILL ANALYTES

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	Green Frog			Osprey		
	TBD	RTV	HQ	TBD	RTV	HQ
arsenic	4.0E+01	5.1E+00	7.9E+00	1.4E–03	5.1E+00	2.7E–04
barium	1.5E+00	1.0E+01	1.5E–01	4.9E–03	1.0E+01	4.8E–04
manganese	2.2E+02	3.7E+02	6.0E–01	5.9E–01	3.7E+02	1.6E–03
nickel	4.3E–01	1.0E+01	4.3E–02	1.5E–03	1.0E+01	1.4E–04
iron	1.0E+03	2.4E+03	4.3E–01	4.3E–01	2.4E+03	1.8E–04
SUMMARY HAZARD INDEX			**9.1E+00**			**2.7E–03**

NOTES: TBD = Total Body Dose (mg/kgBW–day)
RTV = Reference Toxicity Value (mg/kgBW–day)
BW = Body Weight (kg)
HQ = Hazard Quotient calculated by dividing TBD by RTV)

TABLE R-5
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

EXPOSURE CONCENTRATION DATA		ESTIMATED TISSUE LEVELS IN PRIMARY PREY ITEMS				BAF VALUES FOR OTHER PREY ITEMS			
CHEMICAL	AVERAGE CONCENTRATION (mg/kg)	Invert BAF [a]	Tissue Level (mg/kg)	Plant BAF [a]	Tissue Level (mg/kg)	Small Mammal BAF [a]	Small Bird BAF [a]	Reptile/ Amphib. BAF [a]	Fish BAF [a]
aroclor 1260	2.7E-01	2.3E-01	6.2E-02	2.9E-03	7.8E-04	2.3E-01	2.3E-01	2.3E-01	2.3E-01
DDE	5.0E-02	1.4E+00	7.0E-02	1.3E-02	6.5E-04	1.4E+00	1.4E+00	1.4E+00	1.4E+00
DDD	7.0E-02	2.7E-01	1.9E-02	1.3E-02	9.1E-04	2.7E-01	2.7E-01	2.7E-01	2.7E-01
DDT	3.0E-02	1.8E-01	5.4E-03	1.3E-02	3.9E-04	1.8E-01	1.8E-01	1.8E-01	1.8E-01
benzo(a)anthracene	2.2E-01	2.5E-02	5.5E-03	2.2E-02	4.8E-03	2.5E-02	2.5E-02	2.5E-02	2.5E-02
chrysene	3.2E-01	2.5E-02	8.0E-03	2.2E-02	7.0E-03	2.5E-02	2.5E-02	2.5E-02	2.5E-02
fluoranthene	5.0E-01	2.5E-02	1.3E-02	3.2E-02	1.6E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
naphthalene	3.2E-01	2.5E-02	8.0E-03	1.0E-01	3.2E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
phenanthrene	3.8E-01	2.5E-02	9.5E-03	1.0E-01	3.8E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
pyrene	9.7E-01	2.5E-02	2.4E-02	1.0E-01	9.7E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
aluminum	7.9E+03	2.4E-04	1.9E+00	2.4E-04	1.9E+00	2.4E-04	2.4E-04	2.4E-04	2.4E-04
arsenic	4.7E+02	1.1E-01	4.9E+01	2.1E-01	9.9E+01	4.0E-04	4.0E-04	4.0E-04	4.0E-04
barium	1.1E+02	1.3E-02	1.4E+00	1.3E-02	1.4E+00	1.3E-02	1.3E-02	1.3E-02	1.3E-02
beryllium	5.3E-01	1.8E-02	9.5E-03	1.8E-02	9.5E-03	1.8E-02	1.8E-02	1.8E-02	1.8E-02
chromium	2.0E+03	2.5E-04	5.0E-01	7.5E-03	1.5E+01	2.5E-04	2.5E-04	2.5E-04	2.5E-04
cobalt	5.8E+00	1.3E-02	7.5E-02	1.3E-02	7.5E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02
copper	4.0E+01	2.0E-02	8.0E-01	2.0E-02	8.0E-01	2.0E-02	2.0E-02	2.0E-02	2.0E-02
iron	3.6E+04	1.2E-03	4.4E+01	1.2E-03	4.4E+01	1.2E-03	1.2E-03	1.2E-03	1.2E-03
lead	1.3E+02	5.4E-04	7.0E-02	8.0E-03	1.0E+00	5.4E-04	5.4E-04	5.4E-04	5.4E-04
manganese	2.6E+03	1.0E-02	2.6E+01	1.0E-02	2.6E+01	1.0E-02	1.0E-02	1.0E-02	1.0E-02
mercury	1.8E+01	3.7E-02	6.7E-01	7.0E-03	1.3E-01	3.7E-02	3.7E-02	3.7E-02	3.7E-02
nickel	2.3E+01	1.7E-02	3.9E-01	9.0E-02	2.1E+00	1.7E-02	1.7E-02	1.7E-02	1.7E-02
selenium	2.0E+00	2.1E-01	4.2E-01	2.1E-01	4.2E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01
vanadium	2.5E+01	1.6E-02	4.0E-01	1.6E-02	4.0E-01	1.6E-02	1.6E-02	1.6E-02	1.6E-02
zinc	8.9E+01	2.2E-01	2.0E+01	8.0E-01	7.1E+01	2.2E-01	2.2E-01	2.2E-01	2.2E-01
cadmium	9.8E+00	1.1E-01	1.1E+00	6.4E-02	6.3E-01	3.7E-03	3.7E-03	3.7E-03	3.7E-03
thallium	8.3E+00	6.4E-03	5.3E-02	4.0E-03	3.3E-02	6.4E-03	6.4E-03	6.4E-03	6.4E-03

Site Area:	30 acres

TABLE R-5
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Mallard*	*Great Blue Heron*	*Green Frog*	*Painted Turtle*	*Osprey*
aroclor-1260	4.72E-04	6.89E-04	6.30E-03	2.45E-03	6.74E-05
DDE	3.39E-04	6.56E-04	6.33E-03	2.11E-03	7.59E-05
DDD	1.56E-04	2.04E-04	1.89E-03	7.27E-04	2.05E-05
DDT	5.60E-05	6.30E-05	5.71E-04	2.35E-04	5.86E-06
benzo(a)anthracene	3.37E-04	1.54E-04	1.20E-03	8.04E-04	5.97E-06
chrysene	4.90E-04	2.24E-04	1.75E-03	1.17E-03	8.68E-06
fluoranthene	9.24E-04	3.51E-04	2.78E-03	1.93E-03	1.36E-05
naphthalene	1.28E-03	2.24E-04	2.00E-03	1.66E-03	8.68E-06
phenanthrene	1.52E-03	2.66E-04	2.38E-03	1.97E-03	1.03E-05
pyrene	3.89E-03	6.80E-04	6.07E-03	5.03E-03	2.63E-05
aluminum	5.87E+00	3.79E+00	2.43E+01	2.01E+01	2.07E-03
arsenic	3.66E+00	2.98E-01	5.90E+00	4.17E+00	2.03E-04
barium	1.29E-01	6.40E-02	4.66E-01	3.39E-01	1.52E-03
beryllium	7.29E-04	3.38E-04	2.55E-03	1.79E-03	1.03E-05
chromium	1.93E+00	9.49E-01	6.24E+00	5.31E+00	5.39E-04
cobalt	6.94E-03	3.44E-03	2.50E-02	1.82E-02	8.18E-05
copper	5.74E-02	2.60E-02	1.99E-01	1.38E-01	8.61E-04
iron	2.81E+01	1.77E+01	1.15E+02	9.35E+01	4.73E-02
lead	1.23E-01	6.00E-02	3.96E-01	3.36E-01	7.32E-05
manganese	2.87E+00	1.49E+00	1.06E+01	7.91E+00	2.86E-02
mercury	2.01E-02	1.47E-02	1.16E-01	6.73E-02	7.30E-04
nickel	8.42E-02	1.45E-02	1.25E-01	1.10E-01	4.24E-04
selenium	1.57E-02	4.54E-03	4.52E-02	2.40E-02	4.34E-04
vanadium	3.21E-02	1.53E-02	1.13E-01	8.08E-02	4.27E-04
zinc	2.40E+00	2.18E-01	2.71E+00	2.16E+00	2.11E-02
cadmium	3.16E-02	6.63E-03	1.16E-01	6.14E-02	3.90E-05
thallium	7.33E-03	4.43E-03	3.03E-02	2.30E-02	5.76E-05

TABLE R-5
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Muskrat*	*Mink*	*Raccoon*
aroclor 1260	7.80E-04	3.66E-03	3.88E-05
DDE	4.71E-04	3.72E-03	3.44E-05
DDD	2.49E-04	1.09E-03	1.15E-05
DDT	9.25E-05	3.29E-04	3.68E-06
benzo(a)anthracene	5.91E-04	6.39E-04	1.16E-05
chrysene	8.59E-04	9.30E-04	1.69E-05
fluoranthene	1.57E-03	1.45E-03	2.75E-05
naphthalene	1.99E-03	9.30E-04	2.25E-05
phenanthrene	2.36E-03	1.10E-03	2.67E-05
pyrene	6.03E-03	2.82E-03	6.82E-05
aluminum	1.24E+01	1.28E+01	2.88E-01
arsenic	5.33E+00	1.29E+00	4.82E-02
barium	2.44E-01	2.51E-01	4.97E-03
beryllium	1.31E-03	1.35E-03	2.58E-05
chromium	3.78E+00	3.22E+00	7.56E-02
cobalt	1.29E-02	1.32E-02	2.62E-04
copper	1.03E-01	1.06E-01	2.00E-03
iron	5.88E+01	6.06E+01	1.35E+00
lead	2.50E-01	2.13E-01	4.98E-03
manganese	5.37E+00	5.53E+00	1.12E-01
mercury	3.72E-02	6.35E-02	9.90E-04
nickel	1.32E-01	5.73E-02	1.48E-03
selenium	2.43E-02	2.50E-02	3.62E-04
vanadium	5.92E-02	6.10E-02	1.18E-03
zinc	3.46E+00	1.16E+00	2.83E-02
cadmium	4.66E-02	2.88E-02	7.02E-04
thallium	1.47E-02	1.61E-02	3.33E-04

TABLE R-5
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Mallard	(Waterfowl)	11%	87%	0%	0%	0%	2%	0%	3.5	0.5	5.0E-01	0.086	1.177
Great Blue Heron	(Pred Bird)	16%	0%	5%	4%	0%	5%	70%	100	0.5	1.5E-01	0.187	2.95
Green Frog	(Reptile)	70%	10%	0%	7%	0%	3%	10%	0.5	0.75	7.5E-01	0.01	0.037
Painted Turtle	(Herptile)	43%	39%	0%	0%	0%	5%	13%	12	0.75	7.5E-01	0.056	0.834
Osprey	(Pred Bird)	0%	0%	0%	0%	0%	0%	100%	100	0.05	1.5E-02	0.094	1.3

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year the receptor is expected to be found at the study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-5
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet							Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
		Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish					
Muskrat	(Small Mammal)	5%	87%	0%	0%	0%	3%	5%	26	1	1.0E+00	0.065	1.25
Mink	(Carn. Mammal)	20%	0%	25%	0%	0%	3%	52%	35	1	8.6E-01	0.05	0.8
Raccoon	(Omniv. Mammal)	25%	31%	9%	20%	1%	5%	9%	1150	1	2.6E-02	0.22	7.95

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-6
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

CHEMICAL	Mallard			Great Blue Heron			Green Frog		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
aroclor-1260	4.7E-04	2.3E+00	2.1E-04	6.9E-04	2.3E+00	3.0E-04	6.3E-03	2.3E+00	2.7E-03
4,4'-DDE	3.4E-04	1.4E-01	2.4E-03	6.6E-04	2.5E-01	2.6E-03	6.3E-03	7.6E+00	8.3E-04
4,4'-DDD	1.6E-04	1.4E-01	1.1E-03	2.0E-04	2.5E-01	8.2E-04	1.9E-03	7.6E+00	2.5E-04
4,4-DDT	5.6E-05	1.4E-01	4.0E-04	6.3E-05	2.5E-01	2.5E-04	5.7E-04	7.6E+00	7.5E-05
benzo(a)anthracene	3.4E-04	2.0E+00	1.7E-04	1.5E-04	2.0E+00	7.7E-05	1.2E-03	2.0E+00	6.0E-04
chrysene	4.9E-04	9.9E+01	4.9E-06	2.2E-04	9.9E+01	2.3E-06	1.7E-03	9.9E+01	1.8E-05
fluoranthene	9.2E-04	2.5E+02	3.7E-06	3.5E-04	2.5E+02	1.4E-06	2.8E-03	2.5E+02	1.1E-05
naphthalene	1.3E-03	4.1E+01	3.1E-05	2.2E-04	4.1E+01	5.5E-06	2.0E-03	4.1E+01	4.9E-05
phenanthrene	1.5E-03	1.2E+02	1.3E-05	2.7E-04	1.2E+02	2.2E-06	2.4E-03	1.2E+02	2.0E-05
pyrene	3.9E-03	1.3E+02	3.1E-05	6.8E-04	1.3E+02	5.4E-06	6.1E-03	1.3E+02	4.9E-05
aluminum	5.9E+00	4.3E+02	1.4E-02	3.8E+00	4.3E+02	8.9E-03	2.4E+01	4.3E+02	5.7E-02
arsenic	3.7E+00	6.5E+00	5.6E-01	3.0E-01	5.1E+00	5.8E-02	5.9E+00	5.1E+00	1.2E+00
barium	1.3E-01	1.0E+01	1.3E-02	6.4E-02	1.0E+01	6.3E-03	4.7E-01	1.0E+01	4.6E-02
beryllium	7.3E-04	2.2E-01	3.3E-03	3.4E-04	2.2E-01	1.5E-03	2.5E-03	2.2E-01	1.2E-02
chromium	1.9E+00	3.5E+00	5.5E-01	9.5E-01	3.5E+00	2.7E-01	6.2E+00	3.5E+00	1.8E+00
cobalt	6.9E-03	1.3E+01	5.5E-04	3.4E-03	1.3E+01	2.8E-04	2.5E-02	1.3E+01	2.0E-03
copper	5.7E-02	2.9E+01	2.0E-03	2.6E-02	2.9E+01	9.0E-04	2.0E-01	2.9E+01	6.9E-03
iron	2.8E+01	2.4E+03	1.2E-02	1.8E+01	2.4E+03	7.4E-03	1.1E+02	2.4E+03	4.8E-02
lead	1.2E-01	1.8E+00	7.1E-02	6.0E-02	4.4E+00	1.4E-02	4.0E-01	4.4E+00	9.0E-02
manganese	2.9E+00	3.7E+02	7.8E-03	1.5E+00	3.7E+02	4.0E-03	1.1E+01	3.7E+02	2.9E-02
mercury	2.0E-02	2.2E-01	9.1E-02	1.5E-02	1.0E-01	1.5E-01	1.2E-01	8.6E-01	1.3E-01
nickel	8.4E-02	1.0E+01	8.3E-03	1.4E-02	1.0E+01	1.4E-03	1.3E-01	1.0E+01	1.2E-02
selenium	1.6E-02	1.8E+00	9.0E-03	4.5E-03	1.8E+00	2.6E-03	4.5E-02	1.8E+00	2.6E-02
vanadium	3.2E-02	2.0E+00	1.6E-02	1.5E-02	2.0E+00	7.6E-03	1.1E-01	2.0E+00	5.7E-02
zinc	2.4E+00	1.6E+02	1.5E-02	2.2E-01	1.6E+02	1.4E-03	2.7E+00	1.6E+02	1.7E-02
cadmium	3.2E-02	7.6E+00	4.2E-03	6.6E-03	7.6E+00	8.7E-04	1.2E-01	7.6E+00	1.5E-02
thallium	7.3E-03	1.2E+00	6.1E-03	4.4E-03	1.2E+00	3.7E-03	3.0E-02	1.2E+00	2.5E-02
SUMMARY HAZARD INDEX			**1.4E+00**			**5.4E-01**			**3.5E+00**

TABLE R-6
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	Muskrat			Mink			Raccoon		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
aroclor 1260	7.8E-04	3.8E+00	2.1E-04	3.7E-03	3.8E+00	9.6E-04	3.9E-05	3.8E+00	1.0E-05
DDE	4.7E-04	4.8E-01	9.8E-04	3.7E-03	5.0E+00	7.4E-04	3.4E-05	5.0E+00	6.9E-06
DDD	2.5E-04	4.8E-01	5.2E-04	1.1E-03	5.0E+00	2.2E-04	1.2E-05	5.0E+00	2.3E-06
DDT	9.3E-05	4.8E-01	1.9E-04	3.3E-04	5.0E+00	6.6E-05	3.7E-06	5.0E+00	7.4E-07
benzo(a)anthracene	5.9E-04	2.0E+00	3.0E-04	6.4E-04	2.0E+00	3.2E-04	1.2E-05	2.0E+00	5.8E-06
chrysene	8.6E-04	9.9E+01	8.7E-06	9.3E-04	9.9E+01	9.4E-06	1.7E-05	9.9E+01	1.7E-07
fluoranthene	1.6E-03	2.5E+02	6.3E-06	1.5E-03	2.5E+02	5.8E-06	2.8E-05	2.5E+02	1.1E-07
naphthalene	2.0E-03	4.1E+01	4.8E-05	9.3E-04	4.1E+01	2.3E-05	2.3E-05	4.1E+01	5.5E-07
phenanthrene	2.4E-03	1.2E+02	2.0E-05	1.1E-03	1.2E+02	9.2E-06	2.7E-05	1.2E+02	2.2E-07
pyrene	6.0E-03	1.3E+02	4.8E-05	2.8E-03	1.3E+02	2.3E-05	6.8E-05	1.3E+02	5.5E-07
aluminum	1.2E+01	4.3E+02	2.9E-02	1.3E+01	4.3E+02	3.0E-02	2.9E-01	4.3E+02	6.8E-04
arsenic	5.3E+00	7.5E+00	7.1E-01	1.3E+00	2.5E+02	5.2E-03	4.8E-02	2.5E+02	1.9E-04
barium	2.4E-01	1.0E+01	2.4E-02	2.5E-01	1.0E+01	2.5E-02	5.0E-03	1.0E+01	4.9E-04
beryllium	1.3E-03	2.2E-01	5.9E-03	1.3E-03	2.2E-01	6.1E-03	2.6E-05	2.2E-01	1.2E-04
chromium	3.8E+00	4.1E+01	9.3E-02	3.2E+00	4.1E+01	7.9E-02	7.6E-02	4.1E+01	1.9E-03
cobalt	1.3E-02	1.3E+01	1.0E-03	1.3E-02	5.0E+00	2.6E-03	2.6E-04	5.0E+00	5.2E-05
copper	1.0E-01	7.7E+01	1.3E-03	1.1E-01	7.7E+01	1.4E-03	2.0E-03	7.7E+01	2.6E-05
iron	5.9E+01	2.4E+03	2.5E-02	6.1E+01	2.4E+03	2.5E-02	1.3E+00	2.4E+03	5.6E-04
lead	2.5E-01	2.1E+00	1.2E-01	2.1E-01	3.0E+00	7.1E-02	5.0E-03	3.0E+00	1.7E-03
manganese	5.4E+00	3.7E+02	1.5E-02	5.5E+00	2.5E+01	2.2E-01	1.1E-01	2.5E+01	4.5E-03
mercury	3.7E-02	5.0E-01	7.4E-02	6.4E-02	9.0E-02	7.1E-01	9.9E-04	1.0E-01	9.9E-03
nickel	1.3E-01	5.0E+01	2.6E-03	5.7E-02	6.3E+01	9.2E-04	1.5E-03	6.3E+01	2.4E-05
selenium	2.4E-02	1.2E-01	2.0E-01	2.5E-02	1.2E-01	2.1E-01	3.6E-04	1.2E-01	3.0E-03
vanadium	5.9E-02	2.5E+00	2.4E-02	6.1E-02	2.5E+00	2.4E-02	1.2E-03	2.5E+00	4.7E-04
zinc	3.5E+00	1.6E+02	2.2E-02	1.2E+00	1.6E+02	7.3E-03	2.8E-02	1.6E+02	1.8E-04
cadmium	4.7E-02	1.8E+00	2.6E-02	2.9E-02	3.7E+00	7.8E-03	7.0E-04	3.7E+00	1.9E-04
thallium	1.5E-02	1.2E+00	1.2E-02	1.6E-02	1.2E+00	1.3E-02	3.3E-04	1.2E+00	2.8E-04
SUMMARY HAZARD INDEX			**1.4E+00**			**1.4E+00**			**2.4E-02**

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-6
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	*Painted Turtle*			*Osprey*		
	TBD	RTV	HQ	TBD	RTV	HQ
aroclor-1260	2.4E-03	2.3E+00	1.1E-03	6.7E-05	9.0E+00	7.5E-06
DDE	2.1E-03	7.6E+00	2.8E-04	7.6E-05	2.9E-01	2.6E-04
DDD	7.3E-04	7.6E+00	9.6E-05	2.0E-05	2.9E-01	7.1E-05
DDT	2.4E-04	7.6E+00	3.1E-05	5.9E-06	2.9E-01	2.0E-05
benzo(a)anthracene	8.0E-04	2.0E+00	4.0E-04	6.0E-06	2.0E+00	3.0E-06
chrysene	1.2E-03	9.9E+01	1.2E-05	8.7E-06	9.9E+01	8.8E-08
fluoranthene	1.9E-03	2.5E+02	7.7E-06	1.4E-05	2.5E+02	5.4E-08
naphthalene	1.7E-03	4.1E+01	4.0E-05	8.7E-06	4.1E+01	2.1E-07
phenanthrene	2.0E-03	1.2E+02	1.6E-05	1.0E-05	1.2E+02	8.6E-08
pyrene	5.0E-03	1.3E+02	4.0E-05	2.6E-05	1.3E+02	2.1E-07
aluminum	2.0E+01	4.3E+02	4.7E-02	2.1E-03	4.3E+02	4.8E-06
arsenic	4.2E+00	5.1E+00	8.2E-01	2.0E-04	5.1E+00	4.0E-05
barium	3.4E-01	1.0E+01	3.3E-02	1.5E-03	1.0E+01	1.5E-04
beryllium	1.8E-03	2.2E-01	8.1E-03	1.0E-05	2.2E-01	4.7E-05
chromium	5.3E+00	3.5E+00	1.5E+00	5.4E-04	3.5E+00	1.5E-04
cobalt	1.8E-02	1.3E+01	1.5E-03	8.2E-05	1.3E+01	6.5E-06
copper	1.4E-01	2.9E+01	4.8E-03	8.6E-04	2.9E+01	3.0E-05
iron	9.4E+01	2.4E+03	3.9E-02	4.7E-02	2.4E+03	2.0E-05
lead	3.4E-01	4.4E+00	7.6E-02	7.3E-05	4.4E+00	1.7E-05
manganese	7.9E+00	3.7E+02	2.1E-02	2.9E-02	3.7E+02	7.7E-05
mercury	6.7E-02	8.6E-01	7.8E-02	7.3E-04	1.0E-01	7.3E-03
nickel	1.1E-01	1.0E+01	1.1E-02	4.2E-04	1.0E+01	4.2E-05
selenium	2.4E-02	1.8E+00	1.4E-02	4.3E-04	1.8E+00	2.5E-04
vanadium	8.1E-02	2.0E+00	4.0E-02	4.3E-04	2.0E+00	2.1E-04
zinc	2.2E+00	1.6E+02	1.4E-02	2.1E-02	1.6E+02	1.3E-04
cadmium	6.1E-02	7.6E+00	8.1E-03	3.9E-05	7.6E+00	5.1E-06
thallium	2.3E-02	1.2E+00	1.9E-02	5.8E-05	1.2E+00	4.8E-05
SUMMARY HAZARD INDEX			**2.8E+00**			**8.9E-03**

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW -day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-7
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE CONCENTRATION DATA		ESTIMATED TISSUE LEVELS IN PRIMARY PREY ITEMS				BAF VALUES FOR OTHER PREY ITEMS			
CHEMICAL	MAXIMUM CONCENTRATION (mg/kg)	Invert BAF [a]	Tissue Level (mg/kg)	Plant BAF [a]	Tissue Level (mg/kg)	Small Mammal BAF [a]	Small Bird BAF [a]	Reptile/ Amphib. BAF [a]	Fish BAF [a]
aroclor-1260	2.7E-01	2.3E-01	6.2E-02	2.9E-03	7.8E-04	2.3E-01	2.3E-01	2.3E-01	2.3E-01
DDE	1.3E+00	1.4E+00	1.8E+00	1.3E-02	1.7E-02	1.4E+00	1.4E+00	1.4E+00	1.4E+00
DDD	1.8E+00	2.7E-01	4.9E-01	1.3E-02	2.3E-02	2.7E-01	2.7E-01	2.7E-01	2.7E-01
DDT	1.3E-01	1.8E-01	2.3E-02	1.3E-02	1.7E-03	1.8E-01	1.8E-01	1.8E-01	1.8E-01
benzo(a)anthracene	1.1E+00	2.5E-02	2.8E-02	2.2E-02	2.4E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
chrysene	1.5E+00	2.5E-02	3.8E-02	2.2E-02	3.3E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
fluoranthene	3.4E+00	2.5E-02	8.5E-02	3.2E-02	1.1E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
naphthalene	1.6E+00	2.5E-02	4.0E-02	1.0E-01	1.6E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
phenanthrene	2.5E+00	2.5E-02	6.3E-02	1.0E-01	2.5E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
pyrene	4.4E+00	2.5E-02	1.1E-01	1.0E-01	4.4E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
aluminum	2.4E+04	2.4E-04	5.8E+00	2.4E-04	5.8E+00	2.4E-04	2.4E-04	2.4E-04	2.4E-04
arsenic	3.2E+03	1.1E-01	3.4E+02	2.1E-01	6.7E+02	4.0E-04	4.0E-04	4.0E-04	4.0E-04
barium	3.4E+02	1.3E-02	4.5E+00	1.3E-02	4.5E+00	1.3E-02	1.3E-02	1.3E-02	1.3E-02
beryllium	2.7E+00	1.8E-02	4.9E-02	1.8E-02	4.9E-02	1.8E-02	1.8E-02	1.8E-02	1.8E-02
chromium	1.0E+04	2.5E-04	2.5E+00	7.5E-03	7.5E+01	2.5E-04	2.5E-04	2.5E-04	2.5E-04
cobalt	5.9E+01	1.3E-02	7.6E-01	1.3E-02	7.6E-01	1.3E-02	1.3E-02	1.3E-02	1.3E-02
copper	1.3E+02	2.0E-02	2.6E+00	2.0E-02	2.6E+00	2.0E-02	2.0E-02	2.0E-02	2.0E-02
iron	3.3E+05	1.2E-03	4.0E+02	1.2E-03	4.0E+02	1.2E-03	1.2E-03	1.2E-03	1.2E-03
lead	6.3E+02	5.4E-04	3.4E-01	8.0E-03	5.1E+00	5.4E-04	5.4E-04	5.4E-04	5.4E-04
manganese	5.5E+04	1.0E-02	5.5E+02	1.0E-02	5.5E+02	1.0E-02	1.0E-02	1.0E-02	1.0E-02
mercury	1.3E+02	3.7E-02	4.8E+00	7.0E-03	9.1E-01	3.7E-02	3.7E-02	3.7E-02	3.7E-02
nickel	7.9E+01	1.7E-02	1.3E+00	9.0E-02	7.1E+00	1.7E-02	1.7E-02	1.7E-02	1.7E-02
selenium	6.6E+00	2.1E-01	1.4E+00	2.1E-01	1.4E+00	2.1E-01	2.1E-01	2.1E-01	2.1E-01
vanadium	1.7E+02	1.6E-02	2.7E+00	1.6E-02	2.7E+00	1.6E-02	1.6E-02	1.6E-02	1.6E-02
zinc	4.0E+02	2.2E-01	8.9E+01	8.0E-01	3.2E+02	2.2E-01	2.2E-01	2.2E-01	2.2E-01
cadmium	6.0E+01	1.1E-01	6.8E+00	6.4E-02	3.8E+00	3.7E-03	3.7E-03	3.7E-03	3.7E-03
thallium	8.3E+00	6.4E-03	5.3E-02	4.0E-03	3.3E-02	6.4E-03	6.4E-03	6.4E-03	6.4E-03

SITE AREA:	30.0 acres

TABLE R-7
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Mallard*	*Great Blue Heron*	*Green Frog*	*Painted Turtle*	*Osprey*
aroclor-1260	4.72E-04	6.89E-04	6.30E-03	2.45E-03	6.74E-05
DDE	8.80E-03	1.71E-02	1.65E-01	5.49E-02	1.97E-03
DDD	4.01E-03	5.25E-03	4.86E-02	1.87E-02	5.27E-04
DDT	2.43E-04	2.73E-04	2.48E-03	1.02E-03	2.54E-05
benzo(a)anthracene	1.68E-03	7.71E-04	6.01E-03	4.02E-03	2.98E-05
chrysene	2.30E-03	1.05E-03	8.20E-03	5.48E-03	4.07E-05
fluoranthene	6.28E-03	2.38E-03	1.89E-02	1.31E-02	9.22E-05
naphthalene	6.42E-03	1.12E-03	1.00E-02	8.30E-03	4.34E-05
phenanthrene	1.00E-02	1.75E-03	1.56E-02	1.30E-02	6.78E-05
pyrene	1.74E-02	3.05E-03	2.72E-02	2.26E-02	1.18E-04
aluminum	1.77E+01	1.15E+01	7.35E+01	6.07E+01	6.25E-03
arsenic	2.50E+01	2.04E+00	4.04E+01	2.85E+01	1.39E-03
barium	4.11E-01	2.04E-01	1.49E+00	1.08E+00	4.85E-03
beryllium	3.74E-03	1.74E-03	1.31E-02	9.19E-03	5.31E-05
chromium	9.70E+00	4.78E+00	3.14E+01	2.67E+01	2.71E-03
cobalt	7.02E-02	3.48E-02	2.54E-01	1.84E-01	8.28E-04
copper	1.91E-01	8.66E-02	6.61E-01	4.59E-01	2.86E-03
iron	2.55E+02	1.60E+02	1.04E+03	8.50E+02	4.30E-01
lead	6.24E-01	3.04E-01	2.00E+00	1.70E+00	3.70E-04
manganese	5.97E+01	3.10E+01	2.20E+02	1.64E+02	5.94E-01
mercury	1.43E-01	1.05E-01	8.29E-01	4.81E-01	5.22E-03
nickel	2.90E-01	4.99E-02	4.32E-01	3.78E-01	1.46E-03
selenium	5.33E-02	1.54E-02	1.53E-01	8.13E-02	1.47E-03
vanadium	2.16E-01	1.03E-01	7.66E-01	5.45E-01	2.88E-03
zinc	1.09E+01	9.92E-01	1.23E+01	9.85E+00	9.62E-02
cadmium	1.93E-01	4.06E-02	7.10E-01	3.76E-01	2.39E-04
thallium	7.33E-03	4.43E-03	3.03E-02	2.30E-02	5.76E-05

TABLE R-7
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL - FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Muskrat*	*Mink*	*Raccoon*
aroclor-1260	7.80E-04	3.66E-03	3.88E-05
DDE	1.23E-02	9.67E-02	8.96E-04
DDD	6.39E-03	2.81E-02	2.96E-04
DDT	4.01E-04	1.42E-03	1.60E-05
benzo(a)anthracene	2.95E-03	3.20E-03	5.81E-05
chrysene	4.03E-03	4.36E-03	7.92E-05
fluoranthene	1.07E-02	9.88E-03	1.87E-04
naphthalene	9.94E-03	4.65E-03	1.13E-04
phenanthrene	1.55E-02	7.27E-03	1.76E-04
pyrene	2.70E-02	1.26E-02	3.06E-04
aluminum	3.77E+01	3.89E+01	8.74E-01
arsenic	3.63E+01	8.80E+00	3.28E-01
barium	7.62E-01	7.85E-01	1.56E-02
beryllium	6.71E-03	6.92E-03	1.32E-04
chromium	1.90E+01	1.62E+01	3.81E-01
cobalt	1.30E-01	1.34E-01	2.65E-03
copper	3.39E-01	3.49E-01	6.60E-03
iron	5.35E+02	5.51E+02	1.22E+01
lead	1.22E+00	1.03E+00	2.42E-02
manganese	1.13E+02	1.17E+02	2.36E+00
mercury	2.69E-01	4.59E-01	7.15E-03
nickel	4.54E-01	1.97E-01	5.11E-03
selenium	7.85E-02	8.09E-02	1.17E-03
vanadium	3.93E-01	4.05E-01	7.85E-03
zinc	1.57E+01	5.25E+00	1.28E-01
cadmium	2.86E-01	1.79E-01	4.34E-03
thallium	1.47E-02	1.61E-02	3.33E-04

TABLE R-7
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Mallard	(Waterfowl)	11%	87%	0%	0%	0%	2%	0%	3.5	0.5	5.0E-01	0.086	1.177
Great Blue Heron	(Pred Bird)	16%	0%	5%	4%	0%	5%	70%	100	0.5	1.5E-01	0.187	2.95
Green Frog	(Reptile)	70%	10%	0%	7%	0%	3%	10%	0.5	0.75	7.5E-01	0.01	0.037
Painted Turtle	(Herptile)	43%	39%	0%	0%	0%	5%	13%	12	0.75	7.5E-01	0.056	0.834
Osprey	(Pred Bird)	0%	0%	0%	0%	0%	0%	100%	100	0.05	1.5E-02	0.094	1.3

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year the receptor is expected to be found at the study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-7
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Muskrat	(Small Mammal)	5%	87%	0%	0%	0%	3%	5%	26	1	1.0E+00	0.065	1.25
Mink	(Carn. Mammal)	20%	0%	25%	0%	0%	3%	52%	35	1	8.6E-01	0.05	0.8
Raccoon	(Omniv. Mammal)	25%	31%	9%	20%	1%	5%	9%	1150	1	2.6E-02	0.22	7.95

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2a
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year the receptor is expected to be found at the study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-8
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	Mallard			Great Blue Heron			Green Frog		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
aroclor-1260	4.7E-04	2.3E+00	2.1E-04	6.9E-04	2.3E+00	3.0E-04	6.3E-03	2.3E+00	2.7E-03
DDE	8.8E-03	1.4E-01	6.3E-02	1.7E-02	2.5E-01	6.8E-02	1.6E-01	7.6E+00	2.2E-02
DDD	4.0E-03	1.4E-01	2.9E-02	5.2E-03	2.5E-01	2.1E-02	4.9E-02	7.6E+00	6.4E-03
DDT	2.4E-04	1.4E-01	1.7E-03	2.7E-04	2.5E-01	1.1E-03	2.5E-03	7.6E+00	3.3E-04
benzo(a)anthracene	1.7E-03	2.0E+00	8.4E-04	7.7E-04	2.0E+00	3.9E-04	6.0E-03	2.0E+00	3.0E-03
chrysene	2.3E-03	9.9E+01	2.3E-05	1.1E-03	9.9E+01	1.1E-05	8.2E-03	9.9E+01	8.3E-05
fluoranthene	6.3E-03	2.5E+02	2.5E-05	2.4E-03	2.5E+02	9.5E-06	1.9E-02	2.5E+02	7.6E-05
naphthalene	6.4E-03	4.1E+01	1.6E-04	1.1E-03	4.1E+01	2.7E-05	1.0E-02	4.1E+01	2.4E-04
phenanthrene	1.0E-02	1.2E+02	8.4E-05	1.8E-03	1.2E+02	1.5E-05	1.6E-02	1.2E+02	1.3E-04
pyrene	1.7E-02	1.3E+02	1.4E-04	3.1E-03	1.3E+02	2.4E-05	2.7E-02	1.3E+02	2.2E-04
aluminum	1.8E+01	4.3E+02	4.2E-02	1.1E+01	4.3E+02	2.7E-02	7.4E+01	4.3E+02	1.7E-01
arsenic	2.5E+01	6.5E+00	3.9E+00	2.0E+00	5.1E+00	4.0E-01	4.0E+01	5.1E+00	7.9E+00
barium	4.1E-01	1.0E+01	4.0E-02	2.0E-01	1.0E+01	2.0E-02	1.5E+00	1.0E+01	1.5E-01
beryllium	3.7E-03	2.2E-01	1.7E-02	1.7E-03	2.2E-01	7.9E-03	1.3E-02	2.2E-01	5.9E-02
chromium	9.7E+00	3.5E+00	2.8E+00	4.8E+00	3.5E+00	1.4E+00	3.1E+01	3.5E+00	9.0E+00
cobalt	7.0E-02	1.3E+01	5.6E-03	3.5E-02	1.3E+01	2.8E-03	2.5E-01	1.3E+01	2.0E-02
copper	1.9E-01	2.9E+01	6.6E-03	8.7E-02	2.9E+01	3.0E-03	6.6E-01	2.9E+01	2.3E-02
iron	2.6E+02	2.4E+03	1.1E-01	1.6E+02	2.4E+03	6.7E-02	1.0E+03	2.4E+03	4.3E-01
lead	6.2E-01	1.8E+00	3.6E-01	3.0E-01	4.4E+00	6.9E-02	2.0E+00	4.4E+00	4.6E-01
manganese	6.0E+01	3.7E+02	1.6E-01	3.1E+01	3.7E+02	8.4E-02	2.2E+02	3.7E+02	6.0E-01
mercury	1.4E-01	2.2E-01	6.5E-01	1.1E-01	1.0E-01	1.1E+00	8.3E-01	8.6E-01	9.6E-01
nickel	2.9E-01	1.0E+01	2.9E-02	5.0E-02	1.0E+01	4.9E-03	4.3E-01	1.0E+01	4.3E-02
selenium	5.3E-02	1.8E+00	3.0E-02	1.5E-02	1.8E+00	8.8E-03	1.5E-01	1.8E+00	8.7E-02
vanadium	2.2E-01	2.0E+00	1.1E-01	1.0E-01	2.0E+00	5.1E-02	7.7E-01	2.0E+00	3.8E-01
zinc	1.1E+01	1.6E+02	6.8E-02	9.9E-01	1.6E+02	6.2E-03	1.2E+01	1.6E+02	7.7E-02
cadmium	1.9E-01	7.6E+00	2.5E-02	4.1E-02	7.6E+00	5.3E-03	7.1E-01	7.6E+00	9.3E-02
thallium	7.3E-03	1.2E+00	6.1E-03	4.4E-03	1.2E+00	3.7E-03	3.0E-02	1.2E+00	2.5E-02
SUMMARY HAZARD INDEX			8.4E+00			3.3E+00			2.1E+01

TABLE R-8
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	Muskrat			Mink			Raccoon		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
aroclor-1260	7.8E-04	3.8E+00	2.0E-04	3.7E-03	3.8E+00	9.5E-04	3.9E-05	3.8E+00	1.0E-05
DDE	1.2E-02	4.8E-01	2.6E-02	9.7E-02	5.0E+00	1.9E-02	9.0E-04	5.0E+00	1.8E-04
DDD	6.4E-03	4.8E-01	1.3E-02	2.8E-02	5.0E+00	5.6E-03	3.0E-04	5.0E+00	5.9E-05
DDT	4.0E-04	4.8E-01	8.4E-04	1.4E-03	5.0E+00	2.8E-04	1.6E-05	5.0E+00	3.2E-06
benzo(a)anthracene	3.0E-03	2.0E+00	1.5E-03	3.2E-03	2.0E+00	1.6E-03	5.8E-05	2.0E+00	2.9E-05
chrysene	4.0E-03	9.9E+01	4.1E-05	4.4E-03	9.9E+01	4.4E-05	7.9E-05	9.9E+01	8.0E-07
fluoranthene	1.1E-02	2.5E+02	4.3E-05	9.9E-03	2.5E+02	4.0E-05	1.9E-04	2.5E+02	7.5E-07
naphthalene	9.9E-03	4.1E+01	2.4E-04	4.7E-03	4.1E+01	1.1E-04	1.1E-04	4.1E+01	2.7E-06
phenanthrene	1.6E-02	1.2E+02	1.3E-04	7.3E-03	1.2E+02	6.1E-05	1.8E-04	1.2E+02	1.5E-06
pyrene	2.7E-02	1.3E+02	2.2E-04	1.3E-02	1.3E+02	1.0E-04	3.1E-04	1.3E+02	2.4E-06
aluminum	3.8E+01	4.3E+02	8.9E-02	3.9E+01	4.3E+02	9.1E-02	8.7E-01	4.3E+02	2.1E-03
arsenic	3.6E+01	7.5E+00	4.8E+00	8.8E+00	2.5E+02	3.5E-02	3.3E-01	2.5E+02	1.3E-03
barium	7.6E-01	1.0E+01	7.5E-02	7.9E-01	1.0E+01	7.7E-02	1.6E-02	1.0E+01	1.5E-03
beryllium	6.7E-03	2.2E-01	3.1E-02	6.9E-03	2.2E-01	3.1E-02	1.3E-04	2.2E-01	6.0E-04
chromium	1.9E+01	4.1E+01	4.7E-01	1.6E+01	4.1E+01	4.0E-01	3.8E-01	4.1E+01	9.4E-03
cobalt	1.3E-01	1.3E+01	1.0E-02	1.3E-01	5.0E+00	2.7E-02	2.7E-03	5.0E+00	5.3E-04
copper	3.4E-01	7.7E+01	4.4E-03	3.5E-01	7.7E+01	4.6E-03	6.6E-03	7.7E+01	8.6E-05
iron	5.3E+02	2.4E+03	2.2E-01	5.5E+02	2.4E+03	2.3E-01	1.2E+01	2.4E+03	5.1E-03
lead	1.2E+00	2.1E+00	5.8E-01	1.0E+00	3.0E+00	3.4E-01	2.4E-02	3.0E+00	8.1E-03
manganese	1.1E+02	3.7E+02	3.1E-01	1.2E+02	2.5E+01	4.7E+00	2.4E+00	2.5E+01	9.5E-02
mercury	2.7E-01	5.0E-01	5.4E-01	4.6E-01	9.0E-02	5.1E+00	7.2E-03	1.0E-01	7.2E-02
nickel	4.5E-01	5.0E+01	9.1E-03	2.0E-01	6.2E+01	3.2E-03	5.1E-03	6.2E+01	8.2E-05
selenium	7.9E-02	1.2E-01	6.5E-01	8.1E-02	1.2E-01	6.7E-01	1.2E-03	1.2E-01	9.8E-03
vanadium	3.9E-01	2.5E+00	1.6E-01	4.0E-01	2.5E+00	1.6E-01	7.8E-03	2.5E+00	3.1E-03
zinc	1.6E+01	1.6E+02	9.8E-02	5.3E+00	1.6E+02	3.3E-02	1.3E-01	1.6E+02	8.0E-04
cadmium	2.9E-01	1.8E+00	1.6E-01	1.8E-01	3.7E+00	4.8E-02	4.3E-03	3.7E+00	1.2E-03
thallium	1.5E-02	1.2E+00	1.2E-02	1.6E-02	1.2E+00	1.3E-02	3.3E-04	1.2E+00	2.8E-04
SUMMARY HAZARD INDEX			**8.3E+00**			**1.2E+01**			**2.1E-01**

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-8
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL – FORT DEVENS, MA

CHEMICAL	*Painted Turtle*			*Osprey*		
	TBD	RTV	HQ	TBD	RTV	HQ
aroclor-1260	2.4E-03	2.3E+00	1.1E-03	6.7E-05	9.0E+00	7.5E-06
DDE	5.5E-02	7.6E+00	7.2E-03	2.0E-03	2.9E-01	6.8E-03
DDD	1.9E-02	7.6E+00	2.5E-03	5.3E-04	2.9E-01	1.8E-03
DDT	1.0E-03	7.6E+00	1.3E-04	2.5E-05	2.9E-01	8.8E-05
benzo(a)anthracene	4.0E-03	2.0E+00	2.0E-03	3.0E-05	2.0E+00	1.5E-05
chrysene	5.5E-03	9.9E+01	5.5E-05	4.1E-05	9.9E+01	4.1E-07
fluoranthene	1.3E-02	2.5E+02	5.2E-05	9.2E-05	2.5E+02	3.7E-07
naphthalene	8.3E-03	4.1E+01	2.0E-04	4.3E-05	4.1E+01	1.1E-06
phenanthrene	1.3E-02	1.2E+02	1.1E-04	6.8E-05	1.2E+02	5.6E-07
pyrene	2.3E-02	1.3E+02	1.8E-04	1.2E-04	1.3E+02	9.4E-07
aluminum	6.1E+01	4.3E+02	1.4E-01	6.2E-03	4.3E+02	1.5E-05
arsenic	2.9E+01	5.1E+00	5.6E+00	1.4E-03	5.1E+00	2.7E-04
barium	1.1E+00	1.0E+01	1.1E-01	4.9E-03	1.0E+01	4.8E-04
beryllium	9.2E-03	2.2E-01	4.2E-02	5.3E-05	2.2E-01	2.4E-04
chromium	2.7E+01	3.5E+00	7.6E+00	2.7E-03	3.5E+00	7.7E-04
cobalt	1.8E-01	1.3E+01	1.5E-02	8.3E-04	1.3E+01	6.6E-05
copper	4.6E-01	2.9E+01	1.6E-02	2.9E-03	2.9E+01	9.9E-05
iron	8.5E+02	2.4E+03	3.5E-01	4.3E-01	2.4E+03	1.8E-04
lead	1.7E+00	4.4E+00	3.9E-01	3.7E-04	4.4E+00	8.4E-05
manganese	1.6E+02	3.7E+02	4.4E-01	5.9E-01	3.7E+02	1.6E-03
mercury	4.8E-01	8.6E-01	5.6E-01	5.2E-03	1.0E-01	5.2E-02
nickel	3.8E-01	1.0E+01	3.7E-02	1.5E-03	1.0E+01	1.4E-04
selenium	8.1E-02	1.8E+00	4.6E-02	1.5E-03	1.8E+00	8.4E-04
vanadium	5.5E-01	2.0E+00	2.7E-01	2.9E-03	2.0E+00	1.4E-03
zinc	9.8E+00	1.6E+02	6.2E-02	9.6E-02	1.6E+02	6.0E-04
cadmium	3.8E-01	7.6E+00	4.9E-02	2.4E-04	7.6E+00	3.1E-05
thallium	2.3E-02	1.2E+00	1.9E-02	5.8E-05	1.2E+00	4.8E-05
SUMMARY HAZARD INDEX			1.6E+01			6.8E-02

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-9
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

EXPOSURE CONCENTRATION DATA		ESTIMATED TISSUE LEVELS IN PRIMARY PREY ITEMS				BAF VALUES FOR OTHER PREY ITEMS			
CHEMICAL	AVERAGE CONCENTRATION (mg/kg)	Invert BAF [a]	Tissue Level (mg/kg)	Plant BAF [a]	Tissue Level (mg/kg)	Small Mammal BAF [a]	Small Bird BAF [a]	Reptile/ Amphib. BAF [a]	Fish BAF [a]
DDT	6.4E-01	7.0E-03	4.5E-03	1.3E-02	8.3E-03	7.0E-03	7.0E-03	7.0E-03	7.0E-03
DDE	9.0E-02	9.1E-01	8.2E-02	1.3E-02	1.2E-03	9.1E-01	9.1E-01	9.1E-01	9.1E-01
DDD	5.0E-01	2.5E-01	1.3E-01	1.3E-02	6.5E-03	2.5E-01	2.5E-01	2.5E-01	2.5E-01
anthracene	2.7E-01	2.5E-02	6.8E-03	1.0E-01	2.7E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
bis(2-ethylhexyl) phthalate	1.4E+00	2.5E-02	3.5E-02	3.8E-04	5.3E-04	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(a)anthracene	5.1E-01	2.5E-02	1.3E-02	2.2E-02	1.1E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(a)pyrene	1.1E+00	2.5E-02	2.8E-02	1.0E-02	1.1E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
dibenzofuran	1.5E-01	2.5E-02	3.8E-03	1.0E-01	1.5E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(b) fluoranthene	6.4E-01	2.5E-02	1.6E-02	1.2E-02	7.7E-03	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(k)fluoranthene	9.0E-01	2.5E-02	2.3E-02	1.2E-02	1.1E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
chrysene	6.3E-01	2.5E-02	1.6E-02	2.2E-02	1.4E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
fluoranthene	1.6E+00	2.5E-02	4.0E-02	3.2E-02	5.1E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
phenanthrene	7.7E-01	2.5E-02	1.9E-02	1.0E-01	7.7E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
pyrene	2.2E+00	2.5E-02	5.5E-02	1.0E-01	2.2E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
aroclor 1254	2.7E-01	1.0E-01	2.7E-02	2.9E-03	7.8E-04	1.0E-01	1.0E-01	1.0E-01	1.0E-01
aluminum	6.1E+03	1.0E-04	6.1E-01	1.0E-04	6.1E-01	1.0E-04	1.0E-04	1.0E-04	1.0E-04
arsenic	7.8E+01	1.1E-01	8.2E+00	2.1E-01	1.6E+01	1.3E-03	1.3E-03	1.3E-03	1.3E-03
barium	3.7E+01	1.0E-02	3.7E-01	1.0E-02	3.7E-01	1.0E-02	1.0E-02	1.0E-02	1.0E-02
beryllium	1.9E-01	1.1E-01	2.1E-02	1.1E-01	2.1E-02	1.1E-01	1.1E-01	1.1E-01	1.1E-01
iron	1.5E+04	1.6E-03	2.4E+01	1.6E-03	2.4E+01	1.6E-03	1.6E-03	1.6E-03	1.6E-03
chromium	1.5E+01	1.6E-02	2.4E-01	7.5E-03	1.1E-01	1.6E-02	1.6E-02	1.6E-02	1.6E-02
cobalt	3.4E+00	2.8E-02	9.5E-02	2.8E-02	9.5E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02
copper	8.5E+00	6.0E-02	5.1E-01	6.0E-02	5.1E-01	6.0E-02	6.0E-02	6.0E-02	6.0E-02
lead	7.0E+01	7.0E-04	4.9E-02	8.0E-03	5.6E-01	7.0E-04	7.0E-04	7.0E-04	7.0E-04
manganese	6.3E+02	1.4E-02	8.9E+00	1.4E-02	8.9E+00	1.4E-02	1.4E-02	1.4E-02	1.4E-02
mercury	7.7E-02	2.8E+00	2.2E-01	7.0E-03	5.4E-04	2.8E+00	2.8E+00	2.8E+00	2.8E+00
nickel	1.1E+01	3.7E-02	4.0E-01	9.0E-02	9.7E-01	3.7E-02	3.7E-02	3.7E-02	3.7E-02
selenium	2.0E+00	1.2E-01	2.4E-01	1.2E-01	2.4E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01
silver	6.5E-01	1.5E-01	9.8E-02	8.0E-01	5.2E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01
vanadium	1.2E+01	3.3E-02	4.0E-01	3.3E-02	4.0E-01	3.3E-02	3.3E-02	3.3E-02	3.3E-02
zinc	8.2E+01	3.2E-02	2.6E+00	8.0E-01	6.6E+01	3.2E-02	3.2E-02	3.2E-02	3.2E-02
SITE AREA:	3.5 acres								

TABLE R–9
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW–day) [b]

CHEMICAL	***Mallard***	***Great Blue Heron***	***Green Frog***	***Painted Turtle***
DDT	7.50E–04	4.02E–05	2.43E–03	5.55E–04
DDE	4.32E–04	9.13E–05	7.51E–03	7.46E–04
DDD	1.07E–03	1.59E–04	1.26E–02	1.43E–03
anthracene	1.08E–03	2.21E–05	1.69E–03	4.08E–04
bis(2–ethylhexyl) phthalate	1.18E–03	1.15E–04	7.35E–03	1.32E–03
benzo(a)anthracene	7.80E–04	4.17E–05	2.79E–03	5.44E–04
benzo(a)pyrene	1.26E–03	9.00E–05	5.88E–03	1.10E–03
dibenzofuran	6.01E–04	1.23E–05	9.39E–04	2.27E–04
benzo(b)fluoranthene	7.76E–04	5.24E–05	3.43E–03	6.46E–04
benzo(k)fluoranthene	1.09E–03	7.36E–05	4.83E–03	9.08E–04
chrysene	9.64E–04	5.15E–05	3.44E–03	6.72E–04
fluoranthene	2.96E–03	1.31E–04	8.91E–03	1.80E–03
phenanthrene	3.09E–03	6.30E–05	4.82E–03	1.16E–03
pyrene	8.82E–03	1.80E–04	1.38E–02	3.33E–03
aroclor 1254	3.31E–04	4.34E–05	3.21E–03	4.25E–04
aluminum	4.48E+00	3.39E–01	1.86E+01	4.49E+00
arsenic	6.11E–01	5.87E–03	9.86E–01	2.03E–01
barium	4.01E–02	2.43E–03	1.48E–01	3.22E–02
beryllium	8.87E–04	3.26E–05	2.63E–03	4.31E–04
iron	1.20E+01	8.71E–01	4.87E+01	1.15E+01
chromium	1.56E–02	1.09E–03	6.84E–02	1.37E–02
cobalt	5.86E–03	2.87E–04	1.96E–02	3.80E–03
copper	2.45E–02	1.01E–03	7.60E–02	1.34E–02
lead	6.86E–02	3.91E–03	2.21E–01	5.46E–02
manganese	7.81E–01	4.45E–02	2.80E+00	5.89E–01
mercury	9.40E–04	2.31E–04	1.93E–02	1.83E–03
nickel	4.04E–02	1.02E–03	7.79E–02	1.68E–02
selenium	9.85E–03	3.57E–04	2.91E–02	4.72E–03
silver	1.74E–02	1.39E–04	1.58E–02	4.26E–03
vanadium	2.31E–02	1.09E–03	7.60E–02	1.45E–02
zinc	2.16E+00	7.34E–03	1.15E+00	4.59E–01

TABLE R-9
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Muskrat*	*Mink*	*Raccoon*
DDT	1.88E-04	1.47E-04	3.17E-06
DDE	8.34E-05	5.13E-04	4.85E-06
DDD	2.32E-04	8.52E-04	9.05E-06
anthracene	2.26E-04	9.15E-05	2.22E-06
bis(2-ethylhexyl) phthalate	3.22E-04	4.75E-04	7.83E-06
benzo(a)anthracene	1.84E-04	1.73E-04	3.14E-06
benzo(a)pyrene	3.17E-04	3.73E-04	6.43E-06
dibenzofuran	1.25E-04	5.09E-05	1.23E-06
benzo(b) fluoranthene	1.92E-04	2.17E-04	3.78E-06
benzo(k)fluoranthene	2.71E-04	3.05E-04	5.31E-06
chrysene	2.28E-04	2.14E-04	3.88E-06
fluoranthene	6.76E-04	5.43E-04	1.03E-05
phenanthrene	6.44E-04	2.61E-04	6.32E-06
pyrene	1.84E-03	7.46E-04	1.81E-05
aroclor 1254	8.04E-05	2.14E-04	2.62E-06
aluminum	1.29E+00	1.15E+00	2.59E-02
arsenic	1.19E-01	2.54E-02	9.36E-04
barium	1.02E-02	9.13E-03	1.85E-04
beryllium	1.82E-04	1.62E-04	2.48E-06
iron	3.36E+00	3.00E+00	6.64E-02
chromium	4.03E-03	4.30E-03	7.99E-05
cobalt	1.35E-03	1.21E-03	2.19E-05
copper	5.25E-03	4.69E-03	7.69E-05
lead	1.80E-02	1.33E-02	3.11E-04
manganese	1.93E-01	1.73E-01	3.40E-03
mercury	1.70E-04	1.32E-03	1.20E-05
nickel	8.47E-03	4.45E-03	9.28E-05
selenium	2.01E-03	1.79E-03	2.72E-05
silver	3.37E-03	7.13E-04	2.17E-05
vanadium	5.25E-03	4.69E-03	8.33E-05
zinc	4.20E-01	3.14E-02	2.22E-03

TABLE R-9

ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Mallard	(Waterfowl)	11%	87%	0%	0%	0%	2%	0%	3.5	0.5	5.0E-01	0.086	1.177
Great Blue Heron	(Pred Bird)	16%	0%	5%	4%	0%	5%	70%	100	0.5	1.8E-02	0.187	2.95
Green Frog	(Amphibian)	70%	10%	0%	7%	0%	3%	10%	0.5	0.75	7.5E-01	0.01	0.037
Painted Turtle	(Reptile)	43%	39%	0%	0%	0%	5%	13%	12	0.75	2.2E-01	0.056	0.834

NOTES:

[a] Bioaccumulation data presented in: Appendix Q, Table Q-2b

[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.

[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1

[d] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).

[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-9
ESTIMATION OF AVERAGE EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Muskrat	(Small Mammal)	5%	87%	0%	0%	0%	3%	5%	26	1	1.3E-01	0.065	1.25
Mink	(Carn. Mammal)	20%	0%	25%	0%	0%	3%	52%	35	1	1.0E-01	0.05	0.8
Raccoon	(Omniv. Mammal)	25%	31%	9%	20%	1%	5%	9%	1150	1	3.0E-03	0.22	7.95

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2b
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year receptor is expected to be found at study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-10
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

CHEMICAL	Mallard			Great Blue Heron			Green Frog		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
DDT	7.5E-04	1.4E-01	5.4E-03	4.0E-05	2.5E-01	1.6E-04	2.4E-03	7.6E+00	3.2E-04
DDE	4.3E-04	1.4E-01	3.1E-03	9.1E-05	2.5E-01	3.7E-04	7.5E-03	7.6E+00	9.9E-04
DDD	1.1E-03	1.4E-01	7.7E-03	1.6E-04	2.5E-01	6.4E-04	1.3E-02	7.6E+00	1.7E-03
anthracene	1.1E-03	3.3E+03	3.3E-07	2.2E-05	3.3E+03	6.7E-09	1.7E-03	3.3E+03	5.1E-07
bis(2-ethylhexyl) phthalate	1.2E-03	1.9E+01	6.2E-05	1.1E-04	1.9E+01	6.0E-06	7.3E-03	1.9E+01	3.9E-04
benzo(a)anthracene	7.8E-04	2.0E+00	3.9E-04	4.2E-05	2.0E+00	2.1E-05	2.8E-03	2.0E+00	1.4E-03
benzo(a)pyrene	1.3E-03	1.3E+00	1.0E-03	9.0E-05	1.3E+00	7.2E-05	5.9E-03	1.3E+00	4.7E-03
dibenzofuran	6.0E-04	1.3E+02	4.8E-06	1.2E-05	1.3E+02	9.8E-08	9.4E-04	1.3E+02	7.5E-06
benzo(b)fluoranthene	7.8E-04	4.0E+01	1.9E-05	5.2E-05	4.0E+01	1.3E-06	3.4E-03	4.0E+01	8.6E-05
benzo(k)fluoranthene	1.1E-03	7.2E+01	1.5E-05	7.4E-05	7.2E+01	1.0E-06	4.8E-03	7.2E+01	6.7E-05
chrysene	9.6E-04	9.9E+01	9.7E-06	5.2E-05	9.9E+01	5.2E-07	3.4E-03	9.9E+01	3.5E-05
fluoranthene	3.0E-03	2.5E+02	1.2E-05	1.3E-04	2.5E+02	5.2E-07	8.9E-03	2.5E+02	3.6E-05
phenanthrene	3.1E-03	1.2E+02	2.6E-05	6.3E-05	1.2E+02	5.2E-07	4.8E-03	1.2E+02	4.0E-05
pyrene	8.8E-03	1.3E+02	7.1E-05	1.8E-04	1.3E+02	1.4E-06	1.4E-02	1.3E+02	1.1E-04
aroclor 1254	3.3E-04	2.3E+00	1.4E-04	4.3E-05	2.3E+00	1.9E-05	3.2E-03	2.3E+00	1.4E-03
aluminum	4.5E+00	4.3E+02	1.1E-02	3.4E-01	4.3E+02	8.0E-04	1.9E+01	4.3E+02	4.4E-02
arsenic	6.1E-01	6.5E+00	9.4E-02	5.9E-03	5.1E+00	1.2E-03	9.9E-01	5.1E+00	1.9E-01
barium	4.0E-02	1.0E+01	3.9E-03	2.4E-03	1.0E+01	2.4E-04	1.5E-01	1.0E+01	1.5E-02
beryllium	8.9E-04	2.2E-01	4.0E-03	3.3E-05	2.2E-01	1.5E-04	2.6E-03	2.2E-01	1.2E-02
iron	1.2E+01	2.4E+03	5.0E-03	8.7E-01	2.4E+03	3.6E-04	4.9E+01	2.4E+03	2.0E-02
chromium	1.6E-02	3.5E+00	4.5E-03	1.1E-03	3.5E+00	3.1E-04	6.8E-02	3.5E+00	2.0E-02
cobalt	5.9E-03	1.3E+01	4.7E-04	2.9E-04	1.3E+01	2.3E-05	2.0E-02	1.3E+01	1.6E-03
copper	2.4E-02	2.9E+01	8.4E-04	1.0E-03	2.9E+01	3.5E-05	7.6E-02	2.9E+01	2.6E-03
lead	6.9E-02	1.8E+00	3.9E-02	3.9E-03	4.4E+00	8.9E-04	2.2E-01	4.4E+00	5.0E-02
manganese	7.8E-01	3.7E+02	2.1E-03	4.5E-02	3.7E+02	1.2E-04	2.8E+00	3.7E+02	7.6E-03
mercury	9.4E-04	2.2E-01	4.3E-03	2.3E-04	1.0E-01	2.3E-03	1.9E-02	8.6E-01	2.2E-02
nickel	4.0E-02	1.0E+01	4.0E-03	1.0E-03	1.0E+01	1.0E-04	7.8E-02	1.0E+01	7.7E-03
selenium	9.9E-03	1.8E+00	5.6E-03	3.6E-04	1.8E+00	2.0E-04	2.9E-02	1.8E+00	1.7E-02
silver	1.7E-02	1.8E+01	9.6E-04	1.4E-04	1.8E+01	7.7E-06	1.6E-02	1.8E+01	8.8E-04
vanadium	2.3E-02	2.0E+00	1.2E-02	1.1E-03	2.0E+00	5.5E-04	7.6E-02	2.0E+00	3.8E-02
zinc	2.2E+00	1.6E+02	1.4E-02	7.3E-03	1.6E+02	4.6E-05	1.1E+00	1.6E+02	7.2E-03
SUMMARY HAZARD INDEX			**2.2E-01**			**8.6E-03**			**4.7E-01**

TABLE R-10
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

CHEMICAL	Muskrat			Mink			Raccoon		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
DDT	1.9E-04	4.8E-01	3.9E-04	1.5E-04	5.0E+00	2.9E-05	3.2E-06	5.0E+00	6.3E-07
DDE	8.3E-05	4.8E-01	1.7E-04	5.1E-04	5.0E+00	1.0E-04	4.8E-06	5.0E+00	9.7E-07
DDD	2.3E-04	4.8E-01	4.8E-04	8.5E-04	5.0E+00	1.7E-04	9.1E-06	5.0E+00	1.8E-06
anthracene	2.3E-04	3.3E+03	6.8E-08	9.2E-05	3.3E+03	2.8E-08	2.2E-06	3.3E+03	6.7E-10
bis(2-ethylhexyl) phthalate	3.2E-04	1.9E+01	1.7E-05	4.7E-04	1.9E+01	2.5E-05	7.8E-06	1.9E+01	4.1E-07
benzo(a)anthracene	1.8E-04	2.0E+00	9.2E-05	1.7E-04	2.0E+00	8.6E-05	3.1E-06	2.0E+00	1.6E-06
benzo(a)pyrene	3.2E-04	1.3E+00	2.5E-04	3.7E-04	1.3E+00	3.0E-04	6.4E-06	1.3E+00	5.1E-06
dibenzofuran	1.3E-04	3.0E+01	4.2E-06	5.1E-05	3.0E+01	1.7E-06	1.2E-06	3.0E+01	4.1E-08
benzo(b) fluoranthene	1.9E-04	4.0E+01	4.8E-06	2.2E-04	4.0E+01	5.4E-06	3.8E-06	4.0E+01	9.4E-08
benzo(k)fluoranthene	2.7E-04	7.2E+01	3.8E-06	3.1E-04	7.2E+01	4.2E-06	5.3E-06	7.2E+01	7.4E-08
chrysene	2.3E-04	9.9E+01	2.3E-06	2.1E-04	9.9E+01	2.2E-06	3.9E-06	9.9E+01	3.9E-08
fluoranthene	6.8E-04	2.5E+02	2.7E-06	5.4E-04	2.5E+02	2.2E-06	1.0E-05	2.5E+02	4.1E-08
phenanthrene	6.4E-04	1.2E+02	5.4E-06	2.6E-04	1.2E+02	2.2E-06	6.3E-06	1.2E+02	5.3E-08
pyrene	1.8E-03	1.3E+02	1.5E-05	7.5E-04	1.3E+02	6.0E-06	1.8E-05	1.3E+02	1.4E-07
aroclor 1254	8.0E-05	3.8E+00	2.1E-05	2.1E-04	3.8E+00	5.6E-05	2.6E-06	3.8E+00	6.9E-07
aluminum	1.3E+00	4.3E+02	3.0E-03	1.1E+00	4.3E+02	2.7E-03	2.6E-02	4.3E+02	6.1E-05
arsenic	1.2E-01	7.5E+00	1.6E-02	2.5E-02	2.5E+02	1.0E-04	9.4E-04	2.5E+02	3.7E-06
barium	1.0E-02	1.0E+01	1.0E-03	9.1E-03	1.0E+01	9.0E-04	1.9E-04	1.0E+01	1.8E-05
beryllium	1.8E-04	2.2E-01	8.3E-04	1.6E-04	2.2E-01	7.4E-04	2.5E-06	2.2E-01	1.1E-05
iron	3.4E+00	2.4E+03	1.4E-03	3.0E+00	2.4E+03	1.3E-03	6.6E-02	2.4E+03	2.8E-05
chromium	4.0E-03	4.1E+01	9.9E-05	4.3E-03	4.1E+01	1.1E-04	8.0E-05	4.1E+01	2.0E-06
cobalt	1.4E-03	1.3E+01	1.1E-04	1.2E-03	5.0E+00	2.4E-04	2.2E-05	5.0E+00	4.4E-06
copper	5.2E-03	7.7E+01	6.9E-05	4.7E-03	7.7E+01	6.1E-05	7.7E-05	7.7E+01	1.0E-06
lead	1.8E-02	2.1E+00	8.6E-03	1.3E-02	3.0E+00	4.4E-03	3.1E-04	3.0E+00	1.0E-04
manganese	1.9E-01	3.7E+02	5.2E-04	1.7E-01	2.5E+01	6.9E-03	3.4E-03	2.5E+01	1.4E-04
mercury	1.7E-04	5.0E-01	3.4E-04	1.3E-03	9.0E-02	1.5E-02	1.2E-05	1.0E-01	1.2E-04
nickel	8.5E-03	5.0E+01	1.7E-04	4.4E-03	6.3E+01	7.1E-05	9.3E-05	6.3E+01	1.5E-06
selenium	2.0E-03	1.2E-01	1.7E-02	1.8E-03	1.2E-01	1.5E-02	2.7E-05	1.2E-01	2.3E-04
silver	3.4E-03	1.8E+01	1.9E-04	7.1E-04	1.8E+01	3.9E-05	2.2E-05	1.8E+01	1.2E-06
vanadium	5.3E-03	2.5E+00	2.1E-03	4.7E-03	2.5E+00	1.9E-03	8.3E-05	2.5E+00	3.3E-05
zinc	4.2E-01	1.6E+02	2.6E-03	3.1E-02	1.6E+02	2.0E-04	2.2E-03	1.6E+02	1.4E-05
SUMMARY HAZARD INDEX			**5.5E-02**			**5.0E-02**			**7.8E-04**

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-10
ESTIMATION OF AVERAGE RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT - FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL - FORT DEVENS, MA

CHEMICAL	Painted Turtle		
	TBD	RTV	HQ
DDT	5.5E-04	7.6E+00	7.3E-05
DDE	7.5E-04	7.6E+00	9.8E-05
DDD	1.4E-03	7.6E+00	1.9E-04
anthracene	4.1E-04	3.3E+03	1.2E-07
bis(2-ethylhexyl) phthalate	1.3E-03	1.9E+01	6.9E-05
benzo(a)anthracene	5.4E-04	2.0E+00	2.7E-04
benzo(a)pyrene	1.1E-03	1.3E+00	8.8E-04
dibenzofuran	2.3E-04	1.3E+02	1.8E-06
benzo(b)fluoranthene	6.5E-04	7.2E+01	9.0E-06
benzo(k)fluoranthene	9.1E-04	7.2E+01	1.3E-05
chrysene	6.7E-04	9.9E+01	6.8E-06
fluoranthene	1.8E-03	2.5E+02	7.2E-06
phenanthrene	1.2E-03	1.2E+02	9.7E-06
pyrene	3.3E-03	1.3E+02	2.6E-05
aroclor 1254	4.2E-04	2.3E+00	1.8E-04
aluminum	4.5E+00	4.3E+02	1.0E-02
arsenic	2.0E-01	5.1E+00	4.0E-02
barium	3.2E-02	1.0E+01	3.2E-03
beryllium	4.3E-04	2.2E-01	2.0E-03
iron	1.2E+01	2.4E+03	4.8E-03
chromium	1.4E-02	3.5E+00	3.9E-03
cobalt	3.8E-03	1.3E+01	2.9E-04
copper	1.3E-02	2.9E+01	4.6E-04
lead	5.5E-02	4.4E+00	1.2E-02
manganese	5.9E-01	3.7E+02	1.6E-03
mercury	1.8E-03	8.6E-01	2.1E-03
nickel	1.7E-02	1.0E+01	1.7E-03
selenium	4.7E-03	1.8E+00	2.6E-03
silver	4.3E-03	1.8E+01	2.4E-04
vanadium	1.4E-02	2.0E+00	7.2E-03
zinc	4.6E-01	1.6E+02	2.9E-03
SUMMARY HAZARD INDEX			**9.8E-02**

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-11

ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION
REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

EXPOSURE CONCENTRATION DATA		ESTIMATED TISSUE LEVELS IN PRIMARY PREY ITEMS				BAF VALUES FOR OTHER PREY ITEMS			
CHEMICAL	MAXIMUM CONCENTRATION (mg/kg)	Invert BAF [a]	Tissue Level (mg/kg)	Plant BAF [a]	Tissue Level (mg/kg)	Small Mammal BAF [a]	Small Bird BAF [a]	Reptile/ Amphib. BAF [a]	Fish BAF [a]
DDT	1.5E+01	7.0E-03	1.1E-01	1.3E-02	2.0E-01	7.0E-03	7.0E-03	7.0E-03	7.0E-03
DDE	7.2E-01	9.1E-01	6.6E-01	1.3E-02	9.4E-03	9.1E-01	9.1E-01	9.1E-01	9.1E-01
DDD	6.2E+00	2.5E-01	1.6E+00	1.3E-02	8.1E-02	2.5E-01	2.5E-01	2.5E-01	2.5E-01
anthracene	3.0E+00	2.5E-02	7.5E-02	1.0E-01	3.0E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
bis(2-ethylhexyl)phthalate	2.0E+00	2.5E-02	5.0E-02	3.8E-04	7.6E-04	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(a)anthracene	4.0E+00	2.5E-02	1.0E-01	2.2E-02	8.8E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(a)pyrene	6.0E+00	2.5E-02	1.5E-01	1.0E-02	6.0E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
dibenzofuran	6.1E-01	2.5E-02	1.5E-02	1.0E-01	6.1E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(b)fluoranthene	5.0E+00	2.5E-02	1.3E-01	1.2E-02	6.0E-02	2.5E-02	2.5E-02	2.5E-02	2.5E-02
benzo(k)fluoranthene	1.0E+01	2.5E-02	2.5E-01	1.2E-02	1.2E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
chrysene	8.0E+00	2.5E-02	2.0E-01	2.2E-02	1.8E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
fluoranthene	1.0E+01	2.5E-02	2.5E-01	3.2E-02	3.2E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
phenanthrene	6.0E+00	2.5E-02	1.5E-01	1.0E-01	6.0E-01	2.5E-02	2.5E-02	2.5E-02	2.5E-02
pyrene	2.0E+01	2.5E-02	5.0E-01	1.0E-01	2.0E+00	2.5E-02	2.5E-02	2.5E-02	2.5E-02
aroclor 1254	2.7E-01	1.0E-01	2.7E-02	2.9E-03	7.8E-04	1.0E-01	1.0E-01	1.0E-01	1.0E-01
aluminum	1.7E+04	1.0E-04	1.7E+00	1.0E-04	1.7E+00	1.0E-04	1.0E-04	1.0E-04	1.0E-04
arsenic	3.9E+02	1.1E-01	4.1E+01	2.1E-01	8.2E+01	1.3E-03	1.3E-03	1.3E-03	1.3E-03
barium	1.2E+02	1.0E-02	1.2E+00	1.0E-02	1.2E+00	1.0E-02	1.0E-02	1.0E-02	1.0E-02
beryllium	4.1E-01	1.1E-01	4.5E-02	1.1E-01	4.5E-02	1.1E-01	1.1E-01	1.1E-01	1.1E-01
iron	4.5E+04	1.6E-03	7.2E+01	1.6E-03	7.2E+01	1.6E-03	1.6E-03	1.6E-03	1.6E-03
chromium	6.5E+01	1.6E-02	1.0E+00	7.5E-03	4.9E-01	1.6E-02	1.6E-02	1.6E-02	1.6E-02
cobalt	2.0E+01	2.8E-02	5.5E-01	2.8E-02	5.5E-01	2.8E-02	2.8E-02	2.8E-02	2.8E-02
copper	4.3E+01	6.0E-02	2.6E+00	6.0E-02	2.6E+00	6.0E-02	6.0E-02	6.0E-02	6.0E-02
lead	5.7E+02	7.0E-04	4.0E-01	8.0E-03	4.6E+00	7.0E-04	7.0E-04	7.0E-04	7.0E-04
manganese	3.0E+03	1.4E-02	4.2E+01	1.4E-02	4.2E+01	1.4E-02	1.4E-02	1.4E-02	1.4E-02
mercury	7.2E-01	2.8E+00	2.0E+00	7.0E-03	5.0E-03	2.8E+00	2.8E+00	2.8E+00	2.8E+00
nickel	5.4E+01	3.7E-02	2.0E+00	9.0E-02	4.9E+00	3.7E-02	3.7E-02	3.7E-02	3.7E-02
selenium	5.8E+00	1.2E-01	6.9E-01	1.2E-01	6.9E-01	1.2E-01	1.2E-01	1.2E-01	1.2E-01
silver	6.4E+00	1.5E-01	9.5E-01	8.0E-01	5.1E+00	1.5E-01	1.5E-01	1.5E-01	1.5E-01
vanadium	4.9E+01	3.3E-02	1.6E+00	3.3E-02	1.6E+00	3.3E-02	3.3E-02	3.3E-02	3.3E-02
zinc	6.9E+02	3.2E-02	2.2E+01	8.0E-01	5.5E+02	3.2E-02	3.2E-02	3.2E-02	3.2E-02

SITE AREA:	3.5 acres

TABLE R-11
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Mallard*	*Great Blue Heron*	*Green Frog*	*Painted Turtle*
DDT	1.76E-02	2.09E-03	8.09E-02	1.57E-02
DDE	3.46E-03	7.30E-04	6.01E-02	5.97E-03
DDD	1.33E-02	1.98E-03	1.56E-01	1.78E-02
anthracene	1.20E-02	2.45E-04	1.88E-02	4.54E-03
bis(2-ethylhexyl) phthalate	1.69E-03	1.64E-04	1.05E-02	1.88E-03
benzo(a)anthracene	6.12E-03	3.27E-04	2.19E-02	4.26E-03
benzo(a)pyrene	6.89E-03	4.91E-04	3.21E-02	5.98E-03
dibenzofuran	2.45E-03	4.99E-05	3.82E-03	9.23E-04
benzo(b)fluoranthene	6.06E-03	4.09E-04	2.68E-02	5.04E-03
benzo(k)fluoranthene	1.21E-02	8.18E-04	5.37E-02	1.01E-02
chrysene	1.22E-02	6.55E-04	4.37E-02	8.53E-03
fluoranthene	1.85E-02	8.18E-04	5.57E-02	1.12E-02
phenanthrene	2.41E-02	4.91E-04	3.76E-02	9.08E-03
pyrene	8.02E-02	1.64E-03	1.25E-01	3.03E-02
aroclor 1254	3.31E-04	4.34E-05	3.21E-03	4.25E-04
aluminum	1.25E+01	9.45E-01	5.19E+01	1.25E+01
arsenic	3.05E+00	2.93E-02	4.93E+00	1.02E+00
barium	1.25E-01	7.59E-03	4.63E-01	1.01E-01
beryllium	1.91E-03	7.03E-05	5.68E-03	9.30E-04
iron	3.55E+01	2.57E+00	1.44E+02	3.41E+01
chromium	6.70E-02	4.69E-03	2.93E-01	5.89E-02
cobalt	3.40E-02	1.67E-03	1.14E-01	2.21E-02
copper	1.24E-01	5.09E-03	3.83E-01	6.74E-02
lead	5.63E-01	3.20E-02	1.81E+00	4.48E-01
manganese	3.70E+00	2.11E-01	1.33E+01	2.79E+00
mercury	8.79E-03	2.16E-03	1.80E-01	1.71E-02
nickel	2.03E-01	5.13E-03	3.92E-01	8.44E-02
selenium	2.90E-02	1.05E-03	8.56E-02	1.39E-02
silver	1.70E-01	1.36E-03	1.55E-01	4.16E-02
vanadium	9.29E-02	4.39E-03	3.05E-01	5.81E-02
zinc	1.81E+01	6.15E-02	9.64E+00	3.85E+00

TABLE R-11
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

TOTAL BODY DOSE (mg/kgBW-day) [b]

CHEMICAL	*Muskrat*	*Mink*	*Raccoon*
DDT	4.41E-03	3.45E-03	7.43E-05
DDE	6.67E-04	4.11E-03	3.88E-05
DDD	2.88E-03	1.06E-02	1.12E-04
anthracene	2.51E-03	1.02E-03	2.46E-05
bis(2-ethylhexyl)phthalate	4.60E-04	6.78E-04	1.12E-05
benzo(a)anthracene	1.45E-03	1.36E-03	2.46E-05
benzo(a)pyrene	1.73E-03	2.03E-03	3.51E-05
dibenzofuran	5.10E-04	2.07E-04	5.01E-06
benzo(b)fluoranthene	1.50E-03	1.70E-03	2.95E-05
benzo(k)fluoranthene	3.01E-03	3.39E-03	5.90E-05
chrysene	2.89E-03	2.71E-03	4.93E-05
fluoranthene	4.22E-03	3.39E-03	6.42E-05
phenanthrene	5.02E-03	2.03E-03	4.92E-05
pyrene	1.67E-02	6.78E-03	1.64E-04
aroclor 1254	8.04E-05	2.14E-04	2.62E-06
aluminum	3.58E+00	3.20E+00	7.21E-02
arsenic	5.95E-01	1.27E-01	4.68E-03
barium	3.20E-02	2.85E-02	5.79E-04
beryllium	3.92E-04	3.50E-04	5.36E-06
iron	9.94E+00	8.87E+00	1.96E-01
chromium	1.73E-02	1.84E-02	3.43E-04
cobalt	7.84E-03	7.00E-03	1.27E-04
copper	2.65E-02	2.36E-02	3.88E-04
lead	1.48E-01	1.09E-01	2.55E-03
manganese	9.15E-01	8.17E-01	1.61E-02
mercury	1.59E-03	1.23E-02	1.12E-04
nickel	4.26E-02	2.24E-02	4.67E-04
selenium	5.91E-03	5.28E-03	8.01E-05
silver	3.29E-02	6.97E-03	2.12E-04
vanadium	2.11E-02	1.88E-02	3.34E-04
zinc	3.52E+00	2.63E-01	1.86E-02

TABLE R-11
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Mallard	(Waterfowl)	11%	87%	0%	0%	0%	2%	0%	3.5	0.5	5.0E-01	0.086	1.177
Great Blue Heron	(Pred Bird)	16%	0%	5%	4%	0%	5%	70%	100	0.5	1.8E-02	0.187	2.95
Green Frog	(Amphibian)	70%	10%	0%	7%	0%	3%	10%	0.5	0.75	7.5E-01	0.01	0.037
Painted Turtle	(Reptile)	43%	39%	0%	0%	0%	5%	13%	12	0.75	2.2E-01	0.056	0.834

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2b
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year the receptor is expected to be found at the study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-11
ESTIMATION OF RME EXPOSURE TO ORGANISMS VIA FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

EXPOSURE PARAMETERS [c]

Indicator Species		Percent Prey in Diet: Inverts	Plants	Small Mammals	Herpeto-fauna	Birds	Sediment	Fish	Home Range (acres)	ED [d]	SFF [e]	Ingestion Rate (kg/day)	Body Weight (kg)
Muskrat	(Small Mammal)	5%	87%	0%	0%	0%	3%	5%	26	1	1.3E-01	0.065	1.25
Mink	(Carn. Mammal)	20%	0%	25%	0%	0%	3%	52%	35	1	1.0E-01	0.05	0.8
Raccoon	(Omniv. Mammal)	25%	31%	9%	20%	1%	5%	9%	1150	1	3.0E-03	0.22	7.95

NOTES:
[a] Bioaccumulation data presented in: Appendix Q, Table Q-2b
[b] Calculated by summing the products of individual prey type concentrations and percent in diet, multiplying by the SFF and ingestion rate, and then dividing by body weight.
[c] Documentation of exposure parameters presented in: Appendix Q, Table Q-1
[d] ED = Exposure Duration (percentage of year the receptor is expected to be found at the study area).
[e] Site Foraging Frequency (SFF). Calculated by dividing site area by receptor home range and multiplying by the ED (cannot exceed 1).

TABLE R-12
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

CHEMICAL	*Mallard*			*Great Blue Heron*			*Green Frog*		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
DDT	1.8E-02	1.4E-01	1.3E-01	2.1E-03	2.5E-01	8.4E-03	8.1E-02	7.6E+00	1.1E-02
DDE	3.5E-03	1.4E-01	2.5E-02	7.3E-04	2.5E-01	2.9E-03	6.0E-02	7.6E+00	7.9E-03
DDD	1.3E-02	1.4E-01	9.5E-02	2.0E-03	2.5E-01	7.9E-03	1.6E-01	7.6E+00	2.1E-02
anthracene	1.2E-02	3.3E+03	3.6E-06	2.5E-04	3.3E+03	7.4E-08	1.9E-02	3.3E+03	5.7E-06
bis(2-ethylhexyl) phthalate	1.7E-03	1.9E+01	8.9E-05	1.6E-04	1.9E+01	8.6E-06	1.0E-02	1.9E+01	5.5E-04
benzo(a)anthracene	6.1E-03	2.0E+00	3.1E-03	3.3E-04	2.0E+00	1.6E-04	2.2E-02	2.0E+00	1.1E-02
benzo(a)pyrene	6.9E-03	1.3E+00	5.5E-03	4.9E-04	1.3E+00	3.9E-04	3.2E-02	1.3E+00	2.6E-02
dibenzofuran	2.4E-03	1.3E+02	2.0E-05	5.0E-05	1.3E+02	4.0E-07	3.8E-03	1.3E+02	3.1E-05
benzo(b)fluoranthene	6.1E-03	4.0E+01	1.5E-04	4.1E-04	4.0E+01	1.0E-05	2.7E-02	4.0E+01	6.7E-04
benzo(k)fluoranthene	1.2E-02	7.2E+01	1.7E-04	8.2E-04	7.2E+01	1.1E-05	5.4E-02	7.2E+01	7.5E-04
chrysene	1.2E-02	9.9E+01	1.2E-04	6.5E-04	9.9E+01	6.6E-06	4.4E-02	9.9E+01	4.4E-04
fluoranthene	1.8E-02	2.5E+02	7.4E-05	8.2E-04	2.5E+02	3.3E-06	5.6E-02	2.5E+02	2.2E-04
phenanthrene	2.4E-02	1.2E+02	2.0E-04	4.9E-04	1.2E+02	4.1E-06	3.8E-02	1.2E+02	3.1E-04
pyrene	8.0E-02	1.3E+02	6.4E-04	1.6E-03	1.3E+02	1.3E-05	1.3E-01	1.3E+02	1.0E-03
aroclor 1254	3.3E-04	2.3E+00	1.4E-04	4.3E-05	2.3E+00	1.9E-05	3.2E-03	2.3E+00	1.4E-03
aluminum	1.2E+01	4.3E+02	2.9E-02	9.4E-01	4.3E+02	2.2E-03	5.2E+01	4.3E+02	1.2E-01
arsenic	3.1E+00	6.5E+00	4.7E-01	2.9E-02	5.1E+00	5.8E-03	4.9E+00	5.1E+00	9.7E-01
barium	1.3E-01	1.0E+01	1.2E-02	7.6E-03	1.0E+01	7.4E-04	4.6E-01	1.0E+01	4.5E-02
beryllium	1.9E-03	2.2E-01	8.7E-03	7.0E-05	2.2E-01	3.2E-04	5.7E-03	2.2E-01	2.6E-02
iron	3.5E+01	2.4E+03	1.5E-02	2.6E+00	2.4E+03	1.1E-03	1.4E+02	2.4E+03	6.0E-02
chromium	6.7E-02	3.5E+00	1.9E-02	4.7E-03	3.5E+00	1.3E-03	2.9E-01	3.5E+00	8.4E-02
cobalt	3.4E-02	1.3E+01	2.7E-03	1.7E-03	1.3E+01	1.3E-04	1.1E-01	1.3E+01	9.1E-03
copper	1.2E-01	2.9E+01	4.3E-03	5.1E-03	2.9E+01	1.8E-04	3.8E-01	2.9E+01	1.3E-02
lead	5.6E-01	1.8E+00	3.2E-01	3.2E-02	4.4E+00	7.3E-03	1.8E+00	4.4E+00	4.1E-01
manganese	3.7E+00	3.7E+02	1.0E-02	2.1E-01	3.7E+02	5.7E-04	1.3E+01	3.7E+02	3.6E-02
mercury	8.8E-03	2.2E-01	4.0E-02	2.2E-03	1.0E-01	2.2E-02	1.8E-01	8.6E-01	2.1E-01
nickel	2.0E-01	1.0E+01	2.0E-02	5.1E-03	1.0E+01	5.1E-04	3.9E-01	1.0E+01	3.9E-02
selenium	2.9E-02	1.8E+00	1.7E-02	1.0E-03	1.8E+00	6.0E-04	8.6E-02	1.8E+00	4.9E-02
silver	1.7E-01	1.8E+01	9.4E-03	1.4E-03	1.8E+01	7.5E-05	1.5E-01	1.8E+01	8.6E-03
vanadium	9.3E-02	2.0E+00	4.6E-02	4.4E-03	2.0E+00	2.2E-03	3.1E-01	2.0E+00	1.5E-01
zinc	1.8E+01	1.6E+02	1.1E-01	6.2E-02	1.6E+02	3.8E-04	9.6E+00	1.6E+02	6.0E-02
SUMMARY HAZARD INDEX			**1.4E+00**			**6.5E-02**			**2.4E+00**

TABLE R-12
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

CHEMICAL	Muskrat			Mink			Raccoon		
	TBD	RTV	HQ	TBD	RTV	HQ	TBD	RTV	HQ
DDT	4.4E-03	4.8E-01	9.2E-03	3.4E-03	5.0E+00	6.9E-04	7.4E-05	5.0E+00	1.5E-05
DDE	6.7E-04	4.8E-01	1.4E-03	4.1E-03	5.0E+00	8.2E-04	3.9E-05	5.0E+00	7.8E-06
DDD	2.9E-03	4.8E-01	6.0E-03	1.1E-02	5.0E+00	2.1E-03	1.1E-04	5.0E+00	2.2E-05
anthracene	2.5E-03	3.3E+03	7.6E-07	1.0E-03	3.3E+03	3.1E-07	2.5E-05	3.3E+03	7.5E-09
bis(2-ethylhexyl)phthalate	4.6E-04	1.9E+01	2.4E-05	6.8E-04	1.9E+01	3.6E-05	1.1E-05	1.9E+01	5.9E-07
benzo(a)anthracene	1.4E-03	2.0E+00	7.2E-04	1.4E-03	2.0E+00	6.8E-04	2.5E-05	2.0E+00	1.2E-05
benzo(a)pyrene	1.7E-03	1.3E+00	1.4E-03	2.0E-03	1.3E+00	1.6E-03	3.5E-05	1.3E+00	2.8E-05
dibenzofuran	5.1E-04	3.0E+01	1.7E-05	2.1E-04	3.0E+01	6.9E-06	5.0E-06	3.0E+01	1.7E-07
benzo(b)fluoranthene	1.5E-03	4.0E+01	3.8E-05	1.7E-03	4.0E+01	4.2E-05	2.9E-05	4.0E+01	7.4E-07
benzo(k)fluoranthene	3.0E-03	7.2E+01	4.2E-05	3.4E-03	7.2E+01	4.7E-05	5.9E-05	7.2E+01	8.2E-07
chrysene	2.9E-03	9.9E+01	2.9E-05	2.7E-03	9.9E+01	2.7E-05	4.9E-05	9.9E+01	5.0E-07
fluoranthene	4.2E-03	2.5E+02	1.7E-05	3.4E-03	2.5E+02	1.4E-05	6.4E-05	2.5E+02	2.6E-07
phenanthrene	5.0E-03	1.2E+02	4.2E-05	2.0E-03	1.2E+02	1.7E-05	4.9E-05	1.2E+02	4.1E-07
pyrene	1.7E-02	1.3E+02	1.3E-04	6.8E-03	1.3E+02	5.4E-05	1.6E-04	1.3E+02	1.3E-06
aroclor 1254	8.0E-05	3.8E+00	2.1E-05	2.1E-04	3.8E+00	5.6E-05	2.6E-06	3.8E+00	6.9E-07
aluminum	3.6E+00	4.3E+02	8.4E-03	3.2E+00	4.3E+02	7.5E-03	7.2E-02	4.3E+02	1.7E-04
arsenic	6.0E-01	7.5E+00	7.9E-02	1.3E-01	2.5E+02	5.1E-04	4.7E-03	2.5E+02	1.9E-05
barium	3.2E-02	1.0E+01	3.1E-03	2.9E-02	1.0E+01	2.8E-03	5.8E-04	1.0E+01	5.7E-05
beryllium	3.9E-04	2.2E-01	1.8E-03	3.5E-04	2.2E-01	1.6E-03	5.4E-06	2.2E-01	2.4E-05
iron	9.9E+00	2.4E+03	4.1E-03	8.9E+00	2.4E+03	3.7E-03	2.0E-01	2.4E+03	8.2E-05
chromium	1.7E-02	4.1E+01	4.3E-04	1.8E-02	4.1E+01	4.5E-04	3.4E-04	4.1E+01	8.4E-06
cobalt	7.8E-03	1.3E+01	6.3E-04	7.0E-03	5.0E+00	1.4E-03	1.3E-04	5.0E+00	2.5E-05
copper	2.6E-02	7.7E+01	3.5E-04	2.4E-02	7.7E+01	3.1E-04	3.9E-04	7.7E+01	5.1E-06
lead	1.5E-01	2.1E+00	7.0E-02	1.1E-01	3.0E+00	3.6E-02	2.6E-03	3.0E+00	8.5E-04
manganese	9.2E-01	3.7E+02	2.5E-03	8.2E-01	2.5E+01	3.3E-02	1.6E-02	2.5E+01	6.4E-04
mercury	1.6E-03	5.0E-01	3.2E-03	1.2E-02	9.0E-02	1.4E-01	1.1E-04	1.0E-01	1.1E-03
nickel	4.3E-02	5.0E+01	8.5E-04	2.2E-02	6.3E+01	3.6E-04	4.7E-04	6.3E+01	7.5E-06
selenium	5.9E-03	1.2E-01	4.9E-02	5.3E-03	1.2E-01	4.4E-02	8.0E-05	1.2E-01	6.7E-04
silver	3.3E-02	1.8E+01	1.8E-03	7.0E-03	1.8E+01	3.8E-04	2.1E-04	1.8E+01	1.2E-05
vanadium	2.1E-02	2.5E+00	8.4E-03	1.9E-02	2.5E+00	7.5E-03	3.3E-04	2.5E+00	1.3E-04
zinc	3.5E+00	1.6E+02	2.2E-02	2.6E-01	1.6E+02	1.6E-03	1.9E-02	1.6E+02	1.2E-04
SUMMARY HAZARD INDEX			**2.8E-01**			**2.8E-01**			**4.0E-03**

NOTES:
TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

TABLE R-12
ESTIMATION OF RME RISK TO ORGANISMS FROM FOOD AND SEDIMENT INGESTION

REMEDIAL INVESTIGATION ADDENDUM REPORT – FEASIBILITY STUDY FOR GROUP 1A SITES
COLD SPRING BROOK LANDFILL – FORT DEVENS, MA

CHEMICAL	Painted Turtle		
	TBD	RTV	HQ
DDT	1.6E-02	7.6E+00	2.1E-03
DDE	6.0E-03	7.6E+00	7.9E-04
DDD	1.8E-02	7.6E+00	2.3E-03
anthracene	4.5E-03	3.3E+03	1.4E-06
bis(2-ethylhexyl) phthalate	1.9E-03	1.9E+01	9.9E-05
benzo(a)anthracene	4.3E-03	2.0E+00	2.1E-03
benzo(a)pyrene	6.0E-03	1.3E+00	4.8E-03
dibenzofuran	9.2E-04	1.3E+02	7.4E-06
benzo(b)fluoranthene	5.0E-03	4.0E+01	1.3E-04
benzo(k)fluoranthene	1.0E-02	7.2E+01	1.4E-04
chrysene	8.5E-03	9.9E+01	8.6E-05
fluoranthene	1.1E-02	2.5E+02	4.5E-05
phenanthrene	9.1E-03	1.2E+02	7.6E-05
pyrene	3.0E-02	1.3E+02	2.3E-04
aroclor 1254	4.2E-04	2.3E+00	1.8E-04
aluminum	1.3E+01	4.3E+02	2.9E-02
arsenic	1.0E+00	5.1E+00	2.0E-01
barium	1.0E-01	1.0E+01	1.0E-02
beryllium	9.3E-04	2.2E-01	4.2E-03
iron	3.4E+01	2.4E+03	1.4E-02
chromium	5.9E-02	3.5E+00	1.7E-02
cobalt	2.2E-02	1.3E+01	1.7E-03
copper	6.7E-02	2.9E+01	2.3E-03
lead	4.5E-01	4.4E+00	1.0E-01
manganese	2.8E+00	3.7E+02	7.5E-03
mercury	1.7E-02	8.6E-01	2.0E-02
nickel	8.4E-02	1.0E+01	8.4E-03
selenium	1.4E-02	1.8E+00	7.7E-03
silver	4.2E-02	1.8E+01	2.3E-03
vanadium	5.8E-02	2.0E+00	2.9E-02
zinc	3.9E+00	1.6E+02	2.4E-02
SUMMARY HAZARD INDEX			**4.9E-01**

NOTES:

TBD = Total Body Dose (mg/kgBW-day)
RTV = Reference Toxicity Value (mg/kgBW-day)
BW = Body Weight (kg)
HQ = Hazard Quotient (calculated by dividing TBD by RTV)

UNCERTAINTIES ASSOCIATED WITH USEPA SEDIMENT QUALITY CRITERIA FOR 4,4'-DDE

UNCERTAINTIES ASSOCIATED WITH THE USEPA SEDIMENT QUALITY CRITERIA FOR DDE AT FORT DEVENS

The sediment RTV for DDE was derived from the mean SQC for DDT, 0.828 μg/gC (USEPA, 1988), which was then normalized to the specific site conditions by multiplying by the average total organic carbon (TOC). Therefore, at Plow Shop Pond the carbon-normalized SQC is 0.272 μg/g, and at Cold Spring Brook Pond the carbon-normalized SQC is 0.152 μg/g.

The SQC for DDT was derived by USEPA (1988) to represent the sediment concentration that, based on equilibrium partitioning assumptions, is not expected to result in a pore water concentration in excess of the chronic freshwater AWQC (0.001 μg/L) for DDT. The DDT AWQC was derived by USEPA (1984) as a Final Residue Value (FRV) based on the following assumptions, which may be overly conservative with regard to the Fort Devens Group 1A sites:

- The maximum permissible tissue concentration in wildlife was selected by USEPA (1984) as the Lowest Observed Adverse Effect Level (LOAEL) based on a study which found that the brown pelican (*Pelecanus occidentalis*) suffered "reduced productivity" at a tissue residue concentration of 0.15 mg/kg. Another study using this same species found that eggshell thinning occurred at a tissue residue concentration of 0.5 mg/kg. Based on available tissue residue effect data, the pelican is a particularly sensitive species to DDT exposure. The average tissue concentration shown to result in adverse effects in the studies summarized in the USEPA (1984) document (including various birds, and salmonid fish) was 4.1 mg/kg. Exclusive of the two pelican endpoints, the lowest tissue concentration associated with an adverse effect was a finding that Na^+ - K^+ ATPase was inhibited in the rainbow trout (*Salmo gairdneri*) at a tissue concentration of 2.75 mg/kg. Tissue residue concentrations of 2.8 mg/kg were associated with reduced duckling survival in black duck (*Anas rubripes*), reduced survival in sparrow hawks (*Falco sparverius*), and eggshell thinning in screech owls (*Otus asio*). Consequently, the brown pelican appears to be generally an order of magnitude more sensitive to DDT body burdens than other birds and fish evaluated by USEPA (1984).

- The DDE FRV was derived with the assumption that fish prey consumed by piscivores contain 8 percent lipid, based on reported values for the northern anchovy; this contrasts with the findings of the fish sampling program which found that the maximum lipid content of the analyzed fish samples was 4.16 (bullhead) and the average lipid content was typically 2 to 3 percent.

The Freshwater FRV derived in USEPA (1984) was calculated as follows:

$$\text{FRV} = (\text{LOAEL}/((\text{BCF})*(\text{lipid concentration})$$

$$(0.15)/((17{,}870)*(8)) = \underline{0.001}\ \mu\text{g/l}.$$

A revised FRV derived using the above outlined site-specific assumptions would be calculated as follows:

$$(2.75)/((17870)*(4)) = \underline{0.038}\ \mu\text{g/l},$$

This Fort Devens FRV is approximately two orders of magnitude greater than that used by USEPA (1984) in the derivation of the chronic freshwater FRV. Because the site-specific FRV is higher than the value used in developing the freshwater chronic AWQC for DDT, the procedure used by USEPA to develop the AWQC was reexamined in order to derive a more appropriate AWQC, specific to the Group 1A sites.

As defined in the "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Life and its Uses" (USEPA, 1983), the Criterion Average Concentration (i.e., the chronic AWQC) is equal to "the lowest of the Criterion Maximum Concentration, Final Chronic Value, the Final Plant Value, and the Final Residue Value unless other data from tests in which the concentrations of test material were measured show that a lower value should be used". The appropriate terms are presented in the following table:

TERM	VALUE (μg/L)
Final Acute Value (FAV)	1.1[a]
Criterion Maximum Concentration (CMC)	0.55[b]
Final Chronic Value (FCV)	**0.017**[c]
Final Plant Value (FPV)	0.3[d]
Final Residue Value (Fort Devens) (FRV)	0.038[e]

Notes:

a As presented in the AWQC document for DDT (USEPA, 1984).
b Derived by dividing the FAV (1.1 μg/L) by 2.
c No Final Chronic Value presented, the value presented was derived by dividing the FAV by 65, the only species mean acute/chronic ratio data available (USEPA, 1984) for the fathead minnow (*Pimephales promelas*).
d No Final Plant Value presented due to a lack of available data, the value presented is a LOAEL based on effects on growth and morphology in *Chlorella* sp.
e Derived based on site-specific information and likely ecological receptors for Fort Devens, as described above.

Based on the assumption that the FRV is overly conservative and that the site-specific adjustments made are appropriate, the lowest value (i.e., the site-specific chronic AWQC) is the Final Chronic Value of <u>0.017</u> μg/l, which is approximately 17 times greater than the national freshwater chronic criterion of <u>0.001</u> μg/l.

Therefore, for Plow Shop Pond, use of the adjusted AWQC would result in the carbon-normalized SQC (0.272 μg/g) being increased to <u>4.62</u> μg/g. At Cold Spring Brook Pond, the adjusted carbon-normalized SQC would increase from 0.152 μg/g to 2.58 μg/g. These adjusted values may be viewed as site-specific sediment quality criteria for DDE.

FISH TISSUE DATA

MEMORANDUM

To: Paul Exner

From: Kate Kuebler

Date: March 9, 1993

Subject: Validation : Plow Shop Pond and Cold Spring Brook Pond
Project: Fort Devens Feasibility Study for Group 1A Sites
Sampling Dates: October 20 - 23, 1992

Review is complete for the pesticide/PCB organic data packages generated by Aquatec Laboratory pertaining to fish tissue samples collected at Plow Shop Pond and Cold Spring Brook Pond. Analytical results of forty (40) samples were submitted for review, with the following four samples chosen for complete validation: PSP07F, PSP17F, PSP02W, and CSB12F. Additionally, results were submitted for five (5) duplicate fillets. These were treated as "Field Duplicates" and reviewed for duplicate precision. Review was performed following USEPA Region I guidelines. Package documentation was complete with no resubmissions requested. The following is a list of general criteria examined during the validation procedure:

- Data Completeness
- Calibrations
- Blanks
- Surrogate Recoveries
- Matrix Spike Recoveries
- Field Duplicate Precision
- Pesticide Inst. Performance
- Compound Quantitation
- Compound Identification

General Comments

Samples were analyzed by Method 8080 for the Target Compound List (TCL) pesticides and PCBs contained in the USEPA Statement of Work for the Contract Laboratory Program, March 1990. Extracts of the fish tissues were analyzed at 6%, 15%, and 50% dilutions. Analytical results were reported for the 6% aliquots. Due to GPC mechanical problems, several samples had to be re-extracted. These samples were re-named with 'RE' following the original identification.

The data tables referred to in this memo are comprised of the following:

Table 1 : Laboratory Report of Analysis
Table 2 : Validation Report

Several samples had analytical results that exceeded the calibration range. These results were flagged 'X' on Table 1. The samples were diluted and the diluted results were flagged 'D' on Table 1. On Table 2, the diluted result for any compound exceeding calibration was inserted into the initial results and the rest of the diluted results were deleted.

The following subsections summarize the qualifications and comments that have been determined by validation. All criteria listed above were examined and found to be within the specified quality control limits unless discussed below.

Plow Shop Pond - Qualifications

1. Because of contamination of the extraction blank, 4,4'-DDT should be negated in sample PSP05W. This result was qualified as not detected (U) on Table 2.

Plow Shop Pond - Comments

The result for 4,4'-DDE exceeded calibration range in the initial analysis of PSP17WRE. The sample was diluted 5X. Although DDE was not detected in PSP07F and was detected in the duplicate, PSP07F2, duplicate precision criteria were met and no qualification was necessary .

Cold Spring Brook Pond - Qualifications

1. The recovery of the surrogates was less than 10% in the initial analysis of CSB12F. An aliquot of the extract reserved for the laboratory archive was analyzed without GPC cleanup and the surrogate recoveries were acceptable. The results of the initial analysis were rejected and deleted from Table 2. The results of the second analysis were presented on Table 2. The sample was identified by the laboratory as CSB12FRE although it is not a re-extraction.

Cold Spring Brook - Comments

The result for 4,4'-DDD exceeded calibration range in the initial analysis of CSB03W and CSB07W. CSB03W was diluted 2X and CBS07W was diluted 5X. CSB15W was diluted 3X to get the results of both DDE and DDD within calibration range.

MEMORANDUM

To: Paul Exner

From: Kate Kuebler

Date: March 09, 1993

Subject: Validation : Plow Shop Pond and Cold Spring Brook Pond
Project: Fort Devens Feasibility Study for Group 1A Sites
Sampling Dates: October 20 - 23, 1992

Review is complete for the inorganic data packages generated by Aquatec Laboratory pertaining to fish tissue samples collected at Plow Shop Pond and Cold Spring Brook Pond. Analytical results of forty (40) samples were submitted for review, with the following four samples chosen for complete validation: PSP07F, PSP17F, PSP02W, and CSB12F. Additionally, results were submitted for five (5) duplicate fillets. These were treated as "Field Duplicates" and reviewed for duplicate precision. Review was performed following USEPA Region I guidelines. Package documentation was complete with no resubmissions requested. The following is a list of general criteria examined during the validation procedure:

- Data Completeness
- Calibrations
- Blanks
- ICP Interference Check Results
- Matrix Spike Recoveries
- Laboratory Duplicates
- Lab Control Samples
- Furnace AA Results
- Detection Limit Results
- Sample Quantitation
- Field Duplicate Results

General Comments

Samples were prepared for inorganic analyses in accordance with procedures outlined in "Methods for the Determination of Metals in Environmental Samples", EPA/600/4-1/010. Method 245.6 was used for the preparation of samples analyzed for mercury. Method 200.3 was used for the preparation of samples for the remaining elemental analytes with a modification to the final digestion step, substituting nitric acid for hydrochloric acid. This was done to allow for the analysis of arsenic, cadmium, and lead by graphite furnace atomic absorption spectrometry to meet the required sample quantitation limits (SQLs). The samples were analyzed for Target Analyte List (TAL) inorganics according to the USEPA Statement of Work for the Contract Laboratory Program, March 1990.

The data tables referred to in this memo are comprised of the following:

Table 1 : Laboratory Report of Analysis
Table 2 : Validation Report

The following subsections summarize the qualifications that have been determined by validation. All criteria listed above were examined and found to be within the specified quality control limits unless discussed below.

Plow Shop Pond - Qualifications

1. The matrix spike percent recovery for selenium was below QC limits. Selenium results in all PSP samples were estimated (J) on Table 2.

2. In sample PSP07F, the analytical spike recovery for lead was below QC limits. The nondetect lead result in this sample was estimated (UJ) on Table 2.

3. In sample PSP02W, the analytical spike recovery for lead was less than 10%. The nondetect lead result in this sample was rejected (R) on Table 2.

4. In sample PSP02W, the analytical spike recovery for thallium was below QC limits. The nondetect thallium result in this sample was estimated (UJ)on Table 2.

Cold Spring Brook Pond - Qualifications

1. The matrix spike percent recoveries for manganese and mercury were below QC limits. Results for these analytes in all CSB samples were estimated (J) on Table 2.

2. In sample CSB12F, the analytical spike recovery for lead was below QC limits. The nondetect lead result in this sample was estimated (UJ) on Table 2.

Plow Shop Pond Fish Tissue Analysis

Feasibility Study for Group 1A Sites

Inorganic Analysis (mg/kg, wet weight)

Fort Devens, Massachusetts

Laboratory Report of Analysis

Table 1

	Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead
SAMPLE ID:	PSP02W	PSP03W	PSP04W	PSP10W	PSP11W	PSP05F	PSP05W	PSP06F	PSP06W	PSP12F	PSP12W	PSP22F	PSP22W
LAB NUMBER:	173009	173010	173011	173012	173013	173001	173002	173003	173004	173007	173008	173022	173023
DATE SAMPLED:	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/22/92	10/22/92
Aluminum	1.8	1.8	1.6	3.2	4.5	1.3 U	2.4	1.3 U	2.9	1.3 U	1.7	1.3 U	1.3 U
Arsenic	1.3	0.2 U	0.19 U	0.16 U	0.16 U	0.04 U	0.16 U	0.09	0.16 U	0.04 U	0.19 U	0.04 U	0.16 U
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.07 U	0.07 U	0.06 U	0.06 U	0.07 U	0.07 U	0.07 U	0.07 U	0.06 U	0.07 U	0.06 U	0.07 U	0.07 U
Copper	0.48	0.54	0.47	0.44	0.6	0.22	1.3	0.21	0.81	0.19	0.69	0.22	0.56
Chromium	0.49	0.48	0.59	0.93	0.79	0.2 U	0.31	0.24	0.99	0.2 U	0.43	0.19 U	0.2 U
Iron	130	42.4	61.5	75.2	89.5	4.5	22.3	9.5	43.6	6.7	32.1	21	25.9
Lead	0.1 U	0.1 U	0.1 U	0.16	0.1 U	0.1 U	0.18	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	39.1	40.2	58.8	94.7	83.2	0.3 U	6.5	0.29 U	10.6	0.3	16	0.28 U	6.2
Mercury	0.4	0.19	0.54	0.47	0.24	0.31	0.36	0.44	0.28	0.03 U	0.4	0.51	0.28
Nickel	0.8 U	0.78 U	0.76 U	0.8 U	0.77 U	0.8 U	0.8 U	0.78 U	0.8 U	0.77 U	0.8 U	0.75 U	0.78 U
Selenium	0.52	0.52	0.67	0.62	0.42	0.16	0.28	0.16	0.24	0.17	0.31	0.13	0.29
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.8 U	0.78 U	0.76 U	0.8 U	0.77 U	0.73 U	0.8 U	0.78 U	0.8 U	0.77 U	0.8 U	0.75 U	0.78 U
Zinc	25.1	22.2	25.6	29.6	22.6	4.3	14.1	4.9	18.8	5.7	22.3	6.1	14.1
Barium	1.9	1.3	2.4	4.4	3.8	0.24 U	0.5	0.24 U	0.83	0.24 U	1	0.23 U	0.33
Calcium	34600	23300	28200	48800	24800	105	8020	137	14600	153	16500	138	3250
Cobalt	0.12	0.11	0.16	0.1	0.1 U	0.1 U	0.17	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Magnesium	525	496	536	754	529	260	296	253	427	252	459	277	249
Silver	0.2 U	0.2 U	0.19 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.19 U	0.2 U
Sodium	1820	1530	1850	2290	1480	414	1190	500	1230	474	1410	502	1080
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids:	0.28	1.03	0.46	0.16	0.37	0.27	0.62	0.65	0.72	0.48	0.98	0.44	1.56
% Solids:	24	25	27.5	28.3	26.6	18.9	20.4	19.6	23.6	14.2	22	26.2	23.2

U = not detected

Plow Shop Pond Fish Tissue Analysis

Feasibility Study for Group 1A Sites

Inorganic Analysis (mg/kg, wet weight)

Fort Devens, Massachusetts

Laboratory Report of Analysis

Table 1

	Bullhead	Bullhead	Bass	Bass	Bass	Bass	Bass	Bass	Bass	Bass	Bass
SAMPLE ID:	PSP23F	PSP23W	PSP07F	PSO7F2	PSP07W	PSP17F	PS17F2	PSP17W	PSP18F	PS18F2	PSP18W
LAB NUMBER:	173024	173025	173005	178820	173006	173014	178821	173015	173016	178822	173017
DATE SAMPLED:	10/22/92	10/22/92	10/20/92	10/20/92	10/20/92	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92
Aluminum	1.3 U	1.3 U	1.3 U	1.3 U	2.9	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Arsenic	0.15	0.3	0.04 U	0.08 U	0.2 U	0.04 U	0.16 U	0.19 U	0.04 U	0.15 U	0.2 U
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.07 U	0.06 U	0.07 U	0.07 U	0.09	0.07 U	0.07 U	0.06 U	0.06 U	0.06 U	0.07 U
Copper	0.17	0.43	0.11	0.19	0.44	0.15	0.13	0.45	0.08	0.17	0.55
Chromium	0.19	0.25	0.2 U	0.2 U	0.65	0.2 U	0.2 U	0.42	0.2 U	0.2 U	0.44
Iron	27	71.2	7.5	2	12.6	2.7	1.9	11.1	2	1.7	13.3
Lead	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	0.29 U	8	0.3 U	0.3 U	5.1	0.3 U	0.3 U	5.5	0.3 U	0.29 U	8.8
Mercury	0.12	0.09	3.8	3.4	2.2	4	2.1	2.7	1	1.16	0.65
Nickel	0.77 U	0.8 U	0.8 U	0.78 U	0.78 U	0.79 U	0.79 U	0.79 U	0.8 U	0.77 U	0.78 U
Selenium	0.11	0.25	0.17	0.18	0.54	0.12	0.2	0.38	0.1 U	0.11	0.39
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.77 U	0.8 U	0.8 U	0.78 U	0.78 U	0.79 U	0.79 U	0.79 U	0.8 U	0.77 U	0.78 U
Zinc	3.4	12.1	4.3	4.1	17.9	3.7	3.5	13	4.3	4	16.3
Barium	0.23 U	1.3	0.24 U	0.24 U	0.41	0.24 U	0.24 U	0.27	0.24 U	0.23 U	0.6
Calcium	82.8	7870	118	113	35900	130	350	19400	97	627	18800
Cobalt	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.11	0.1 U
Magnesium	264	303	336	290	671	344	294	508	269	300	522
Silver	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Sodium	343	1120	396	503	2020	290	391	1340	351	439	1460
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids:	0.31	0.48	0.18	0.2	2.49	0.34	0.4	3.27	0.21	0.3	2.45
% Solids:	17.6	18.8	24.1	20.6	27.3	21.8	21.8	34	21.1	23.3	26.1

U = not detected

Plow Shop Pond Fish Tissue Analysis

Feasibility Study for Group 1A Sites

Inorganic Analysis (mg/kg, wet weight)

Fort Devens, Massachusetts

Laboratory Report of Analysis

Table 1

	Bass	Bass	Bass	Bass	Bass	Bass
SAMPLE ID:	PSP19F	PS19F2	PSP19W	PSP20F	PS20F2	PSP20W
LAB NUMBER:	173018	178823	173019	173020	178824	173021
DATE SAMPLED:	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92
Aluminum	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	2.1
Arsenic	0.04 U	0.16 U	0.19 U	0.04 U	0.04 U	0.19 U
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.07 U	0.06 U	0.07 U	0.07 U	0.06 U	0.06 U
Copper	0.09	0.18	0.9	0.12	0.24	0.54
Chromium	0.2 U	0.2 U	0.32	0.2 U	0.2 U	0.33
Iron	1.7	2.2	24.6	2.9	1.9	19.9
Lead	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	0.3 U	0.3 U	7.2	0.3 U	0.3 U	5.1
Mercury	1.1	0.89	0.65	1.4	1.23	0.72
Nickel	0.8 U	0.8 U	0.76 U	0.8 U	0.79 U	0.78 U
Selenium	0.1 U	0.1 U	0.32	0.1 U	0.1 U	0.26
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.8 U	0.8 U	0.76 U	0.8 U	0.79 U	0.78 U
Zinc	3.8	3.8	15.7	4.5	4.8	18.9
Barium	0.24 U	0.24 U	0.99	0.24 U	0.24 U	0.63
Calcium	92	222	12300	88.7	343	14100
Cobalt	0.1 U	0.1 U	0.1 U	0.1 U	0.11	0.1 U
Magnesium	278	306	420	284	270	431
Silver	0.2 U	0.2 U	0.19 U	0.2 U	0.2 U	0.2 U
Sodium	283	446	1530	343	509	1460
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids:	0.13	0.29	1.25	0.27	0.1	1.79
% Solids:	20.1	21.1	25.5	19	20	24.4

U = not detected

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites
Inorganic Analysis (mg/kg, wet weight)
Fort Devens, Massachusetts
Validation Report
Table 2

	Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead
SAMPLE ID:	PSP02W	PSP03W	PSP04W	PSP10W	PSP11W	PSP05F	PSP05W	PSP06F	PSP06W	PSP12F	PSP12W	PSP22F	PSP22W
LAB NUMBER:	173009 #	173010	173011	173012	173013	173001	173002	173003	173004	173007	173008	173022	173023
DATE SAMPLED:	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/20/92	10/22/92	10/22/92
Aluminum	1.8	1.8	1.6	3.2	4.5	1.3 U	2.4	1.3 U	2.9	1.3 U	1.7	1.3 U	1.3 U
Arsenic	1.3	0.2 U	0.19 U	0.16 U	0.16 U	0.04 U	0.16 U	0.09	0.16 U	0.04 U	0.19 U	0.04 U	0.16 U
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.07 U	0.07 U	0.06 U	0.06 U	0.07 U	0.07 U	0.07 U	0.07 U	0.06 U	0.07 U	0.06 U	0.07 U	0.07 U
Copper	0.48	0.54	0.47	0.44	0.6	0.22	1.3	0.21	0.81	0.19	0.69	0.22	0.56
Chromium	0.49	0.48	0.59	0.93	0.79	0.2 U	0.31	0.24	0.99	0.2 U	0.43	0.19 U	0.2 U
Iron	130	42.4	61.5	75.2	89.5	4.5	22.3	9.5	43.6	6.7	32.1	21	25.9
Lead	0.1 R	0.1 U	0.1 U	0.16	0.1 U	0.1 U	0.18	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	39.1	40.2	58.8	94.7	83.2	0.3 U	6.5	0.29 U	10.6	0.3	16	0.28 U	6.2
Mercury	0.4	0.19	0.54	0.47	0.24	0.31	0.36	0.44	0.28	0.03 U	0.4	0.51	0.28
Nickel	0.8 U	0.78 U	0.76 U	0.8 U	0.77 U	0.8 U	0.8 U	0.78 U	0.8 U	0.77 U	0.8 U	0.75 U	0.78 U
Selenium	0.52 J	0.52 J	0.67 J	0.62 J	0.42 J	0.16 J	0.28 J	0.16 J	0.24 J	0.17 J	0.31 J	0.13 J	0.29 J
Thallium	0.1 J	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.8 U	0.78 U	0.76 U	0.8 U	0.77 U	0.73 U	0.8 U	0.78 U	0.8 U	0.77 U	0.8 U	0.75 U	0.78 U
Zinc	25.1	22.2	25.6	29.6	22.6	4.3	14.1	4.9	18.8	5.7	22.3	6.1	14.1
Barium	1.9	1.3	2.4	4.4	3.8	0.24 U	0.5	0.24 U	0.83	0.24 U	1	0.23 U	0.33
Calcium	34600	23300	28200	48800	24800	105	8020	137	14600	153	16500	138	3250
Cobalt	0.12	0.11	0.16	0.1	0.1 U	0.1 U	0.17	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Magnesium	525	496	536	754	529	260	296	253	427	252	459	277	249
Silver	0.2 U	0.2 U	0.19 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.19 U	0.2 U
Sodium	1820	1530	1850	2290	1480	414	1190	500	1230	474	1410	502	1080
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids:	0.28	1.03	0.46	0.16	0.37	0.27	0.62	0.65	0.72	0.48	0.98	0.44	1.56
% Solids:	24	25	27.5	28.3	26.6	18.9	20.4	19.6	23.6	14.2	22	26.2	23.2

U = not detected
# = validated sample
J = estimated value
R = rejected

W = whole fish
F = fillet
F2 = duplicate fillet

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites
Inorganic Analysis (mg/kg, wet weight)
Fort Devens, Massachusetts
Validation Report
Table 2

	Bullhead	Bullhead	Bass	Bass	Bass	Bass	Bass	Bass	Bass	Bass	Bass
SAMPLE ID:	PSP23F	PSP23W	PSP07F	PSO7F2	PSP07W	PSP17F	PS17F2	PSP17W	PSP18F	PS18F2	PSP18W
LAB NUMBER:	173024	173025	173005 #	178820	173006	173014 #	178821	173015	173016	178822	173017
DATE SAMPLED:	10/22/92	10/22/92	10/20/92	10/20/92	10/20/92	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92
Aluminum	1.3 U	1.3 U	1.3 U	1.3 U	2.9	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Arsenic	0.15	0.3	0.04 U	0.08 U	0.2 U	0.04 U	0.16 U	0.19 U	0.04 U	0.15 U	0.2 U
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.07 U	0.06 U	0.07 U	0.07 U	0.09	0.07 U	0.07 U	0.06 U	0.06 U	0.06 U	0.07 U
Copper	0.17	0.43	0.11	0.19	0.44	0.15	0.13	0.45	0.08	0.17	0.55
Chromium	0.19	0.25	0.2 U	0.2 U	0.65	0.2 U	0.2 U	0.42	0.2 U	0.2 U	0.44
Iron	27	71.2	7.5	2	12.6	2.7	1.9	11.1	2	1.7	13.3
Lead	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	0.29 U	8	0.3 U	0.3 U	5.1	0.3 U	0.3 U	5.5	0.3 U	0.29 U	8.8
Mercury	0.12	0.09	3.8	3.4	2.2	4	2.1	2.7	1	1.16	0.65
Nickel	0.77 U	0.8 U	0.8 U	0.78 U	0.78 U	0.79 U	0.79 U	0.79 U	0.8 U	0.77 U	0.78 U
Selenium	0.11 J	0.25 J	0.17 J	0.18 J	0.54 J	0.12 J	0.2 J	0.38 J	0.1 UJ	0.11 J	0.39 J
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.77 U	0.8 U	0.8 U	0.78 U	0.78 U	0.79 U	0.79 U	0.79 U	0.8 U	0.77 U	0.78 U
Zinc	3.4	12.1	4.3	4.1	17.9	3.7	3.5	13	4.3	4	16.3
Barium	0.23 U	1.3	0.24 U	0.24 U	0.41	0.24 U	0.24 U	0.27	0.24 U	0.23 U	0.6
Calcium	82.8	7870	118	113	35900	130	350	19400	97	627	18800
Cobalt	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.11	0.1 U
Magnesium	264	303	336	290	671	344	294	508	269	300	522
Silver	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Sodium	343	1120	396	503	2020	290	391	1340	351	439	1460
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids:	0.31	0.48	0.18	0.2	2.49	0.34	0.4	3.27	0.21	0.3	2.45
% Solids:	17.6	18.8	24.1	20.6	27.3	21.8	21.8	34	21.1	23.3	26.1

U = not detected
# = validated sample
J = estimated value
R = rejected

W = whole fish
F = fillet
F2 = duplicate fillet

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites

Inorganic Analysis (mg/kg, wet weight)

Fort Devens, Massachusetts
Validation Report
Table 2

	Bass	Bass	Bass	Bass	Bass	Bass
SAMPLE ID:	PSP19F	PS19F2	PSP19W	PSP20F	PS20F2	PSP20W
LAB NUMBER:	173018	178823	173019	173020	178824	173021
DATE SAMPLED:	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92	10/22/92
Aluminum	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	2.1
Arsenic	0.04 U	0.16 U	0.19 U	0.04 U	0.04 U	0.19 U
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.07 U	0.06 U	0.07 U	0.07 U	0.06 U	0.06 U
Copper	0.09	0.18	0.9	0.12	0.24	0.54
Chromium	0.2 U	0.2 U	0.32	0.2 U	0.2 U	0.33
Iron	1.7	2.2	24.6	2.9	1.9	19.9
Lead	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	0.3 U	0.3 U	7.2	0.3 U	0.3 U	5.1
Mercury	1.1	0.89	0.65	1.4	1.23	0.72
Nickel	0.8 U	0.8 U	0.76 U	0.8 U	0.79 U	0.78 U
Selenium	0.1 UJ	0.1 UJ	0.32 J	0.1 UJ	0.1 UJ	0.26 J
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.8 U	0.8 U	0.76 U	0.8 U	0.79 U	0.78 U
Zinc	3.8	3.8	15.7	4.5	4.8	18.9
Barium	0.24 U	0.24 U	0.99	0.24 U	0.24 U	0.63
Calcium	92	222	12300	88.7	343	14100
Cobalt	0.1 U	0.1 U	0.1 U	0.1 U	0.11	0.1 U
Magnesium	278	306	420	284	270	431
Silver	0.2 U	0.2 U	0.19 U	0.2 U	0.2 U	0.2 U
Sodium	283	446	1530	343	509	1460
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids:	0.13	0.29	1.25	0.27	0.1	1.79
% Solids:	20.1	21.1	25.5	19	20	24.4

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Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Groups 1A Sites
Pesticide/PCB Organics Analysis (ug/kg, wet weight)
Fort Devens, Massachusetts
Laboratory Report of Analysis
Table 1

	Bluegill	Bluegill	Bluegill	Bluegill	Bluegill	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead
SAMPLE ID:	PSP02W	PSP03W	PSP04W	PSP10W	PSP11W	PSP05F	PSP05W	PSP06F	PSP06W	PSP12F	PSP12W
LAB NUMBER:	173009 #	173010	173011	173012	173013	173001	173002	173003	173004	173007	173008
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/18/93	02/18/93	02/18/93	12/18/93	02/18/93	01/23/93	02/17/93	01/23/93	02/17/93	01/23/93	02/17/93
alpha-BHC	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
beta-BHC	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
delta-BHC	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
gamma-BHC (Lindane)	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Heptachlor	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Aldrin	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Heptachlor epoxide	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Endosulfan I	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Dieldrin	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
4,4'-DDE	9.6 U	29	21	9.6 U	10 U	20 U	15	20 U	9.7 U	19 U	17
Endrin	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
Endosulfan II	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
4,4'-DDD	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
Endosulfan sulfate	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
4,4'-DDT	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	13 B	20 U	14 B	19 U	9.9 U
Methoxychlor	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Endrin Ketone	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
Endrin aldehyde	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
alpha-Chlordane	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
gamma-Chlordane	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Toxaphene	96 U	97 U	99 U	96 U	100 U	200 U	97 U	200 U	97 U	190 U	99 U
Aroclor-1016	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1221	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1232	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1242	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1248	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1254	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1260	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U

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W = whole fish
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DL = diluted

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Groups 1A Sites
Pesticide/PCB Organics Analysis (ug/kg, wet weight)
Fort Devens, Massachusetts
Laboratory Report of Analysis
Table 1

	Bullhead	Bullhead	Bullhead	Bullhead	Bass	Bass	Bass	Bass	Bass	Bass	Bass
SAMPLE ID:	PSP22F	PSP22W	PSP23F	PSP23W	PSP07F	PSP07F2	PSP07WRE	PSP17F	PSP17F2	PSP17WRE	PSP17WREDL
LAB NUMBER:	173022	173023	173024	173025	173005 #	178820	173006R1	173014 #	178821	173015R1	173015R2
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	01/23/93	02/18/93	01/23/93	02/18/93	02/17/93	02/24/93	02/19/93	02/18/93	02/25/93	02/19/93	02/25/93
alpha-BHC	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
beta-BHC	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
delta-BHC	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
gamma-BHC (Lindane)	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
Heptachlor	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
Aldrin	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
Heptachlor epoxide	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
Endosulfan I	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
Dieldrin	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	50 U
4,4'-DDE	21 U	33	10 U	14	9.6 U	15	150	23	31	380 X	416 D
Endrin	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	50 U
Endosulfan II	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	50 U
4,4'-DDD	21 U	12	10 U	9.9 U	9.6 U	9.8 U	35	9.9 U	9.5 U	110	89 D
Endosulfan sulfate	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	50 U
4,4'-DDT	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	12	50 U
Methoxychlor	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Endrin Ketone	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	50 U
Endrin aldehyde	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	50 U
alpha-Chlordane	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
gamma-Chlordane	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	25 U
Toxaphene	210 U	100 U	100 U	99 U	96 U	98 U	98 U	99 U	95 U	99 U	500 U
Aroclor-1016	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Aroclor-1221	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Aroclor-1232	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Aroclor-1242	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Aroclor-1248	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Aroclor-1254	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	250 U
Aroclor-1260	100 U	50 U	50 U	50 U	48 U	49 U	130	50 U	48 U	330	250 U

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DL = diluted

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Groups 1A Sites
Pesticide/PCB Organics Analysis (ug/kg, wet weight)
Fort Devens, Massachusetts
Laboratory Report of Analysis
Table 1

	Bass	Bass	Bass	Bass	Bass	Bass	Bass	Bass	Bass
SAMPLE ID:	PSP18F	PSP18F2	PSP18WRE	PSP19F	PSP19F2	PSP19WRE	PSP20F	PSP20F2	PSP20WRE
LAB NUMBER:	173016	178822	173017R1	173018	178823	173019R1	173020	178824	173021R1
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/18/93	02/25/93	02/19/93	02/18/93	02/25/93	02/19/93	02/18/93	02/25/93	02/20/93
alpha-BHC	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
beta-BHC	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
delta-BHC	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
gamma-BHC (Lindane)	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Heptachlor	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Aldrin	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Heptachlor epoxide	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Endosulfan I	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Dieldrin	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
4,4'-DDE	10 U	9.9 U	82	9.6 U	9.8 U	84	9.9 U	9.9 U	140
Endrin	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
Endosulfan II	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
4,4'-DDD	10 U	9.9 U	21	9.6 U	9.8 U	32	9.9 U	9.9 U	30
Endosulfan sulfate	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
4,4'-DDT	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
Methoxychlor	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Endrin Ketone	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
Endrin aldehyde	10 U	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
alpha-Chlordane	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
gamma-Chlordane	5 U	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Toxaphene	100 U	99 U	99 U	96 U	98 U	97 U	99 U	99 U	95 U
Aroclor-1016	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1221	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1232	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1242	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1248	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1254	50 U	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1260	50 U	50 U	63	48 U	49 U	61	50 U	50 U	100

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DL = diluted

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DL = diluted

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Groups 1A Sites
Pesticide/PCB Organics Analysis (mg/kg, wet weight)
Fort Devens, Massachusetts
Validation Report
Table 2

SAMPLE ID:	PSP02W	PSP03W	PSP04W	PSP10W	PSP11W	PSP05F	PSP05W	PSP06F	PSP06W	PSP12F	PSP12W
LAB NUMBER:	173009 #	173010	173011	173012	173013	173001	173002	173003	173004	173007	173008
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/18/93	02/18/93	02/18/93	12/18/93	02/18/93	01/23/93	02/17/93	01/23/93	02/17/93	01/23/93	02/17/93
alpha-BHC	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
beta-BHC	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
delta-BHC	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
gamma-BHC (Lindane)	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Heptachlor	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Aldrin	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Heptachlor epoxide	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Endosulfan I	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Dieldrin	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
4,4'-DDE	9.6 U	29	21	9.6 U	10 U	20 U	15	20 U	9.7 U	19 U	17
Endrin	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
Endosulfan II	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
4,4'-DDD	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
Endosulfan sulfate	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
4,4'-DDT	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	13 U	20 U	14 B	19 U	9.9 U
Methoxychlor	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Endrin Ketone	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
Endrin aldehyde	9.6 U	9.7 U	9.9 U	9.6 U	10 U	20 U	9.7 U	20 U	9.7 U	19 U	9.9 U
alpha-Chlordane	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
gamma-Chlordane	4.8 U	4.9 U	5 U	4.8 U	5 U	10 U	4.9 U	9.8 U	4.9 U	9.3 U	5 U
Toxaphene	96 U	97 U	99 U	96 U	100 U	200 U	97 U	200 U	97 U	190 U	99 U
Aroclor-1016	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1221	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1232	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1242	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1248	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1254	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U
Aroclor-1260	48 U	49 U	50 U	48 U	50 U	100 U	49 U	98 U	49 U	93 U	50 U

U = not detected
# = validated sample
D = diluted result

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Groups 1A Sites
Pesticide/PCB Organics Analysis (mg/kg, wet weight)
Fort Devens, Massachusetts
Validation Report
Table 2

SAMPLE ID:	PSP22F	PSP22W	PSP23F	PSP23W	PSP07F	PSP07F2	PSP07WRE	PSP17F	PSP17F2	PSP17WRE	PSP18F
LAB NUMBER:	173022	173023	173024	173025	173005 #	178820	173006R1	173014 #	178821	173015R1	173016
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	01/23/93	02/18/93	01/23/93	02/18/93	02/17/93	02/24/93	02/19/93	02/18/93	02/25/93	02/19/93	02/18/93
alpha-BHC	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
beta-BHC	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
delta-BHC	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
gamma-BHC (Lindane)	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
Heptachlor	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
Aldrin	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
Heptachlor epoxide	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
Endosulfan I	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
Dieldrin	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	10 U
4,4'-DDE	21 U	33	10 U	14	9.6 U.	15	150	23	31	416	10 U
Endrin	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	10 U
Endosulfan II	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	10 U
4,4'-DDD	21 U	12	10 U	9.9 U	9.6 U	9.8 U	35	9.9 U	9.5 U	110	10 U
Endosulfan sulfate	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	10 U
4,4'-DDT	21 U	10 U	10 U	9.9 U	9.6 B	9.8 U	9.8 U	9.9 U	9.5 U	12	10 U
Methoxychlor	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Endrin Ketone	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	10 U
Endrin aldehyde	21 U	10 U	10 U	9.9 U	9.6 U	9.8 U	9.8 U	9.9 U	9.5 U	9.9 U	10 U
alpha-Chlordane	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
gamma-Chlordane	10 U	5 U	5 U	5 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	5 U	5 U
Toxaphene	210 U	100 U	100 U	99 U	96 U	98 U	98 U	99 U	95 U	99 U	100 U
Aroclor-1016	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Aroclor-1221	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Aroclor-1232	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Aroclor-1242	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Aroclor-1248	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Aroclor-1254	100 U	50 U	50 U	50 U	48 U	49 U	49 U	50 U	48 U	50 U	50 U
Aroclor-1260	100 U	50 U	50 U	50 U	48 U	49 U	130	50 U	48 U	330	50 U

U = not detected
# = validated sample
D = diluted result

Plow Shop Pond Fish Tissue Analysis
Feasibility Study for Groups 1A Sites
Pesticide/PCB Organics Analysis (mg/kg, wet weight)
Fort Devens, Massachusetts
Validation Report
Table 2

SAMPLE ID:	PSP18F2	PSP18WRE	PSP19F	PSP19F2	PSP19WRE	PSP20F	PSP20F2	PSP20WRE
LAB NUMBER:	178822	173017R1	173018	178823	173019R1	173020	178824	173021R1
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/25/93	02/19/93	02/18/93	02/25/93	02/19/93	02/18/93	02/25/93	02/20/93
alpha-BHC	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
beta-BHC	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
delta-BHC	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
gamma-BHC (Lindane)	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Heptachlor	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Aldrin	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Heptachlor epoxide	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Endosulfan I	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Dieldrin	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
4,4'-DDE	9.9 U	82	9.6 U	9.8 U	84	9.9 U	9.9 U	140
Endrin	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
Endosulfan II	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
4,4'-DDD	9.9 U	21	9.6 U	9.8 U	32	9.9 U	9.9 U	30
Endosulfan sulfate	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
4,4'-DDT	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
Methoxychlor	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Endrin Ketone	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
Endrin aldehyde	9.9 U	9.7 U	9.6 U	9.8 U	9.7 U	9.9 U	9.9 U	9.5 U
alpha-Chlordane	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
gamma-Chlordane	5 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	5 U	4.7 U
Toxaphene	99 U	99 U	96 U	98 U	97 U	99 U	99 U	95 U
Aroclor-1016	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1221	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1232	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1242	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1248	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1254	50 U	49 U	48 U	49 U	49 U	50 U	50 U	47 U
Aroclor-1260	50 U	63	48 U	49 U	61	50 U	50 U	100

U = not detected
# = validated sample
D = diluted result

Cold Spring Brook Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites
Inorganic Analysis (mg/kg wet weight)
Fort Devens, Massachusetts
Laboratory Report of Analysis
Table 1

	P. seed	P. seed	P. seed	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Pickerel	Pickerel	Pickerel	Pickerel	Pickerel	Pickerel
SAMPLE ID:	CSB13W	CSB14W	CSB15W	CSB07W	CSB08W	CSB09W	CSB10F	CSB11F	CSB12F	CSB01W	CSB02W	CSB03W	CSB04F	CSB05F	CSB06F
LAB NUMBER:	173044	173045	173046	173041	173042	173043	173032	173034	173036 #	173038	173039	173040	173026	173028	173030
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
Aluminum	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.6 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Arsenic	0.2 U	0.27	0.16 U	0.19 U	0.2 U	0.16 U	0.04 U	0.22	0.32	0.07 U	0.16 U	0.2 U	0.14	0.18	0.32
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.05 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.06 U	0.06 U	0.07 U	0.06 U	0.07 U	0.07 U	0.07 U	0.07 U	0.07 U	0.06 U	0.06 U	0.07 U	0.07 U	0.07 U	0.07 U
Copper	0.39	0.41	0.37	0.39	0.68	0.57	0.3	0.33	0.26	0.62	0.67	0.46	0.35	0.18	0.35
Chromium	0.33	0.33	0.23	0.21	0.43	0.2 U	0.24 U	0.2 U	0.2 U	0.27	0.23	0.2 U	0.2 U	0.19 U	0.2 U
Iron	41.5	24.6	32.7	35.9	29.3	21.4	8.1	7.1	9.1	11.6	13.4	15.3	7.5	1.83	3
Lead	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	12	10.4	7.6	5.8	10.4	5.1	0.36 U	0.29 U	0.3 U	14.1	8.7	6	0.58	1	0.3 U
Mercury	0.15	0.24	0.08	0.09	0.14	0.13	0.26	0.23	0.15	0.23	0.47	0.39	0.37	0.46	0.36
Nickel	0.8 U	0.8 U	0.8 U	0.8 U	0.77 U	0.78 U	0.96 U	0.77 U	0.79 U	0.78 U	0.79 U	0.78 U	0.79 U	0.75 U	0.8 U
Selenium	0.24	0.1 U	0.45	0.2	0.41	0.24	0.22	0.19	0.15	0.1 U	0.25	0.17	0.16	0.24	0.14
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.8 U	0.8 U	0.8 U	0.8 U	0.77 U	0.78 U	0.72 U	0.77 U	0.79 U	0.78 U	0.79 U	0.78 U	0.79 U	0.75 U	0.8 U
Zinc	24.1	21.7	17.2	12.8	21.4	12.4	6.1	6.5	5.4	51.3	41.4	37.4	3.6	5.9	5.2
Barium	0.64	0.54	0.24	0.24 U	0.41	0.24	0.29 U	0.23 U	0.24 U	0.52	0.39	0.24 U	0.24 U	0.23 U	0.24 U
Calcium	15400	15500	8510	7820	19100	8500	110	94	93.3	10600	7940	4940	388	505	114
Cobalt	0.11	0.1 U	0.2	0.12	0.1 U	0.16	0.12 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Magnesium	461	464	325	316	513	305	243	235	229	426	388	350	305	329	274
Silver	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Sodium	1180	1280	1060	997	1370	1040	343	354	406	1050	1170	912	375	377	455
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.3 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids	0.89	0.58	2.1	4.16	3.17	0.79	0.39	0.67	0.64	0.38	1.5	1.4	0.17	0.29	0.23
% Solids	26.3	25.9	26.7	28.6	22.4	22.2	19.2	22.1	19.3	25.4	23.4	29.7	20.5	20	19.4

U = not detected
# = validated sample

W = whole fish
F = fillet

Cold Spring Brook Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites

Inorganic Analysis (mg/kg wet weight)

Fort Devens, Massachusetts
Validation Report
Table 2

	P. seed	P. seed	P. seed	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Bullhead	Pickerel	Pickerel	Pickerel	Pickerel	Pickerel	Pickerel
SAMPLE ID:	CSB13W	CSB14W	CSB15W	CSB07W	CSB08W	CSB09W	CSB10F	CSB11F	CSB12F	CSB01W	CSB02W	CSB03W	CSB04F	CSB05F	CSB06F
LAB NUMBER:	173044	173045	173046	173041	173042	173043	173032	173034	173036 #	173038	173039	173040	173026	173028	173030
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
Aluminum	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.6 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Arsenic	0.2 U	0.27	0.16 U	0.19 U	0.2 U	0.16 U	0.04 U	0.22	0.32	0.07 U	0.16 U	0.2 U	0.14	0.18	0.32
Beryllium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.05 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Cadmium	0.06 U	0.06 U	0.07 U	0.06 U	0.07 U	0.07 U	0.07 U	0.07 U	0.07 U	0.06 U	0.06 U	0.07 U	0.07 U	0.07 U	0.07 U
Copper	0.39	0.41	0.37	0.39	0.68	0.57	0.3	0.33	0.26	0.62	0.67	0.46	0.35	0.18	0.35
Chromium	0.33	0.33	0.23	0.21	0.43	0.2 U	0.24 U	0.2 U	0.2 U	0.27	0.23	0.2 U	0.2 U	0.19 U	0.2 U
Iron	41.5	24.6	32.7	35.9	29.3	21.4	8.1	7.1	9.1	11.6	13.4	15.3	7.5	1.83	3
Lead	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 UJ	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Manganese	12 J	10.4 J	7.6 J	5.8 J	10.4 J	5.1 J	0.36 UJ	0.29 UJ	0.3 UJ	14.1 J	8.7 J	6 J	0.58 J	1 J	0.3 UJ
Mercury	0.15 J	0.24 J	0.08 J	0.09 J	0.14 J	0.13 J	0.26 J	0.23 J	0.15 J	0.23 J	0.47 J	0.39 J	0.37 J	0.46 J	0.36 J
Nickel	0.8 U	0.8 U	0.8 U	0.8 U	0.77 U	0.78 U	0.96 U	0.77 U	0.79 U	0.78 U	0.79 U	0.78 U	0.79 U	0.75 U	0.8 U
Selenium	0.24	0.1 U	0.45	0.2	0.41	0.24	0.22	0.19	0.15	0.1 U	0.25	0.17	0.16	0.24	0.14
Thallium	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Vanadium	0.8 U	0.8 U	0.8 U	0.8 U	0.77 U	0.78 U	0.72 U	0.77 U	0.79 U	0.78 U	0.79 U	0.78 U	0.79 U	0.75 U	0.8 U
Zinc	24.1	21.7	17.2	12.8	21.4	12.4	6.1	6.5	5.4	51.3	41.4	37.4	3.6	5.9	5.2
Barium	0.64	0.54	0.24	0.24 U	0.41	0.24	0.29 U	0.23 U	0.24 U	0.52	0.39	0.24 U	0.24 U	0.23 U	0.24 U
Calcium	15400	15500	8510	7820	19100	8500	110	94	93.3	10600	7940	4940	388	505	114
Cobalt	0.11	0.1 U	0.2	0.12	0.1 U	0.16	0.12 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Magnesium	461	464	325	316	513	305	243	235	229	426	388	350	305	329	274
Silver	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Sodium	1180	1280	1060	997	1370	1040	343	354	406	1050	1170	912	375	377	455
Antimony	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.3 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
% Lipids	0.89	0.58	2.1	4.16	3.17	0.79	0.39	0.67	0.64	0.38	1.5	1.4	0.17	0.29	0.23
% Solids	26.3	25.9	26.7	28.6	22.4	22.2	19.2	22.1	19.3	25.4	23.4	29.7	20.5	20	19.4

U = not detected
# = validated sample
J = estimated value

W = whole fish
F = fillet

Cold Spring Brook Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites
Pesticide/PCB Organics Analysis (ug/kg, wet weight)
Fort Devens, Massachusetts
Laboratory Report of Analysis
Table 1

SAMPLE ID:	CSB13W	CSB14W	CSB15W	CSB15WDL	CSB07W	CSB07WDL	CSB08W	CSB09W	CSB10F	CSB11F	CSB12F
LAB NUMBER:	173044	173045	173046	173046D1	173041	173041D1	173042	173043	173032	173034	173036 #
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/23/93	02/24/93	02/24/93	02/25/93	02/22/93	02/25/93	02/23/93	02/23/93	01/22/93	01/22/93	01/22/93
alpha-BHC	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
beta-BHC	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
delta-BHC	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
gamma-BHC (Lindane)	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
Heptachlor	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
Aldrin	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
Heptachlor epoxide	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
Endosulfan I	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
Dieldrin	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
4,4'-DDE	58	22	170 X	170 D	150	140 D	73	31	36 U	22 U	17 U
Endrin	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
Endosulfan II	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
4,4'-DDD	97	19	220 X	230 D	360 X	340 D	130	34	36 U	50	17 U
Endosulfan sulfate	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
4,4'-DDT	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
Methoxychlor	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U
Endrin Ketone	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
Endrin aldehyde	9.9 U	9.7 U	10 U	30 U	9.9 U	50 U	9.9 U	9.9 U	36 U	22 U	17 U
alpha-Chlordane	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
gamma-Chlordane	5 U	4.9 U	5 U	15 U	5 U	25 U	5 U	5 U	18 U	11 U	8.6 U
Toxaphene	99 U	97 U	100 U	300 U	99 U	500 U	99 U	99 U	360 U	220 U	170 U
Aroclor-1016	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U
Aroclor-1221	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U
Aroclor-1232	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U
Aroclor-1242	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U
Aroclor-1248	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U
Aroclor-1254	50 U	49 U	50 U	150 U	52	250 U	50 U	50 U	180 U	110 U	86 U
Aroclor-1260	50 U	49 U	50 U	150 U	50 U	250 U	50 U	50 U	180 U	110 U	86 U

U = not detected
X = exceeds calibration range
D = diluted result

W = whole fish
F = fillet
Re = re-extraction
D = diluted

Cold Spring Brook Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites
Pesticide/PCB Organics Analysis (ug/kg, wet weight)
Fort Devens, Massachusetts
Laboratory Report of Analysis
Table 1

SAMPLE ID:	CSB12FRE	CSB01W	CSB02W	CSB03W	CSB03WDL	CSB04F	CSB05F	CSB06F
LAB NUMBER:	173036R1 #	173038	173039	173040	173040D1	173026	173028	173030
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/18/93	02/22/93	02/22/93	02/22/93	02/25/93	01/22/93	01/22/93	01/22/93
alpha-BHC	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
beta-BHC	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
delta-BHC	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
gamma-BHC (Lindane)	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
Heptachlor	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
Aldrin	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
Heptachlor epoxide	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
Endosulfan I	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
Dieldrin	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
4,4'-DDE	21	26	61	150	150 D	9.3 U	12	10 U
Endrin	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
Endosulfan II	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
4,4'-DDD	33	38	67	180 X	160 D	9.3 U	10 U	10 U
Endosulfan sulfate	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
4,4'-DDT	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
Methoxychlor	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Endrin Ketone	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
Endrin aldehyde	17 U	9.6 U	10 U	10 U	20 U	9.3 U	10 U	10 U
alpha-Chlordane	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
gamma-Chlordane	8.6 U	4.8 U	5 U	5 U	10 U	4.6 U	5 U	5 U
Toxaphene	170 U	96 U	100 U	100 U	200 U	93 U	100 U	100 U
Aroclor-1016	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Aroclor-1221	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Aroclor-1232	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Aroclor-1242	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Aroclor-1248	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Aroclor-1254	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U
Aroclor-1260	86 U	48 U	50 U	50 U	100 U	46 U	50 U	50 U

U = not detected
X = exceeds calibration range
D = diluted result

W = whole fish
F = fillet
Re = re-extraction
D = diluted

Cold Spring Brook Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites

Pesticide/PCB Organics Analysis (mg/kg wet weight)

Fort Devens, Massachusetts
Validation Report
Table 2

SAMPLE ID:	CSB13W	CSB14W	CSB15W	CSB07W	CSB08W	CSB09W	CSB10F	CSB11F	CSB12FRE	CSB01W
LAB NUMBER:	173044	173045	173046	173041	173042	173043	173032	173034	173036R1 #	173038
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/23/93	02/24/93	02/24/93	02/22/93	02/23/93	02/23/93	01/22/93	01/22/93	02/18/93	02/22/93
alpha-BHC	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
beta-BHC	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
delta-BHC	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
gamma-BHC (Lindane)	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
Heptachlor	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
Aldrin	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
Heptachlor epoxide	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
Endosulfan I	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
Dieldrin	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
4,4'-DDE	58	22	170	150	73	31	36 U	22 U	21	26
Endrin	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
Endosulfan II	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
4,4'-DDD	97	19	230	340	130	34	36 U	50	33	38
Endosulfan sulfate	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
4,4'-DDT	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
Methoxychlor	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U
Endrin Ketone	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
Endrin aldehyde	9.9 U	9.7 U	10 U	9.9 U	9.9 U	9.9 U	36 U	22 U	17 U	9.6 U
alpha-Chlordane	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
gamma-Chlordane	5 U	4.9 U	5 U	5 U	5 U	5 U	18 U	11 U	8.6 U	4.8 U
Toxaphene	99 U	97 U	100 U	99 U	99 U	99 U	360 U	220 U	170 U	96 U
Aroclor-1016	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U
Aroclor-1221	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U
Aroclor-1232	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U
Aroclor-1242	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U
Aroclor-1248	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U
Aroclor-1254	50 U	49 U	50 U	52	50 U	50 U	180 U	110 U	86 U	48 U
Aroclor-1260	50 U	49 U	50 U	50 U	50 U	50 U	180 U	110 U	86 U	48 U

U = not detected
# = validated sample

Cold Spring Brook Pond Fish Tissue Analysis
Feasibility Study for Group 1A Sites
Pesticide/PCB Organics Analysis (mg/kg wet weight)
Fort Devens, Massachusetts
Validation Report
Table 2

SAMPLE ID:	CSB02W	CSB03W	CSB04F	CSB05F	CSB06F
LAB NUMBER:	173039	173040	173026	173028	173030
DATE SAMPLED:	10/23/92	10/23/92	10/23/92	10/23/92	10/23/92
DATE ANALYZED:	02/22/93	02/22/93	01/22/93	01/22/93	01/22/93
alpha-BHC	5 U	5 U	4.6 U	5 U	5 U
beta-BHC	5 U	5 U	4.6 U	5 U	5 U
delta-BHC	5 U	5 U	4.6 U	5 U	5 U
gamma-BHC (Lindane)	5 U	5 U	4.6 U	5 U	5 U
Heptachlor	5 U	5 U	4.6 U	5 U	5 U
Aldrin	5 U	5 U	4.6 U	5 U	5 U
Heptachlor epoxide	5 U	5 U	4.6 U	5 U	5 U
Endosulfan I	5 U	5 U	4.6 U	5 U	5 U
Dieldrin	10 U	10 U	9.3 U	10 U	10 U
4,4'-DDE	61	150	9.3 U	12	10 U
Endrin	10 U	10 U	9.3 U	10 U	10 U
Endosulfan II	10 U	10 U	9.3 U	10 U	10 U
4,4'-DDD	67	160	9.3 U	10 U	10 U
Endosulfan sulfate	10 U	10 U	9.3 U	10 U	10 U
4,4'-DDT	10 U	10 U	9.3 U	10 U	10 U
Methoxychlor	50 U	50 U	46 U	50 U	50 U
Endrin Ketone	10 U	10 U	9.3 U	10 U	10 U
Endrin aldehyde	10 U	10 U	9.3 U	10 U	10 U
alpha-Chlordane	5 U	5 U	4.6 U	5 U	5 U
gamma-Chlordane	5 U	5 U	4.6 U	5 U	5 U
Toxaphene	100 U	100 U	93 U	100 U	100 U
Aroclor-1016	50 U	50 U	46 U	50 U	50 U
Aroclor-1221	50 U	50 U	46 U	50 U	50 U
Aroclor-1232	50 U	50 U	46 U	50 U	50 U
Aroclor-1242	50 U	50 U	46 U	50 U	50 U
Aroclor-1248	50 U	50 U	46 U	50 U	50 U
Aroclor-1254	50 U	50 U	46 U	50 U	50 U
Aroclor-1260	50 U	50 U	46 U	50 U	50 U

U = not detected
# = validated sample

SUPPLEMENTAL RI LEVEL 3 DATA

USEPA 1992 DERMAL GUIDANCE SUMMARY

USEPA 1992 DERMAL GUIDANCE SUMMARY

USEPA Region I has recommended that the agency's guidance document entitled "Dermal Exposure Assessment: Principles and Applications", Interim Report, January 1992 (USEPA, 1992d) be followed in assessing the health risks associated with dermal contact with COPCs at Shepley's Hill Landfill and Cold Spring Brook Landfill. This appendix contains a description of how information provided in the dermal guidance document is used in the Supplemental Human Health Risk Assessments for the two sites.

DEVELOPMENT OF DOSE/RESPONSE VALUES FOR USE IN DERMAL RISK CALCULATIONS

As recommended in the USEPA guidance document, the risks associated with calculated absorbed doses for the dermal route of exposure should be evaluated using Reference Doses (RfDs) and Cancer Slope Factors (CSFs) which are specific to absorbed doses. Most oral RfDs and CSFs are based on administered dose rather than absorbed dose (trichloroethylene's CSF is a notable exception). It is therefore necessary to adjust toxicity values which are based on administered doses so that they can be used for the evaluation of absorbed doses. For dermal exposures, the toxicity values are adjusted as follows:

$$RfD_{adjusted} = RfD_{oral} \text{ X } ABSEFF$$

$$CSF_{adjusted} = CSF_{oral} / ABSEFF$$

where: ABSEFF is the absorption efficiency in the study that is the basis of the oral toxicity value.

ABSORBED DOSE CALCULATION - DERMAL EXPOSURE TO WATER

The permeability constant approach described in Chapter 5 of the dermal guidance document is used for dermal exposures to contaminants in water.

For inorganics, the **steady state approach** is used. The dose absorbed per unit area per event is:

$$DA_{event} = PC\ CW\ t_{event}\ CF_1\ CF_2$$

where:

DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
PC	=	Permeability constant from water (cm/hr)
CW	=	Concentration of chemical in water (μg/liter)
t_{event}	=	Duration of a single event (hr/event)
CF_1	=	Units conversion factor (liter/ 10^3 cm^3)
CF_2	=	Units conversion factor (mg/ 10^3 μg)

For organics, the "**unsteady-state approach**" is used. The dose absorbed per unit area per event is:

$$DA_{event} = 2\ PC\ CW\ CF_3\ CF_4\ (6\ T\ t_{event} / \pi)^{0.5}$$

where:

$$t_{event} < t^*$$

and

$$DA_{event} = PC\ CW\ CF_5\ CF_6\ ((t_{event}/(1 + B)) + 2\ T\ ((1 + 3\ B) / (1 + B)))$$

where:

$$t_{event} > t^*$$

where:

PC	=	Permeability constant (cm/hr)
CW	=	Concentration of chemical in water (μg/liter)
T	=	l_{sc}^2 / 6 D_{sc} (hr)
L_{sc}	=	Thickness of stratum corneum (10 um)

D_{sc}	=	Stratum corneum diffusion coefficient (cm^2/hr)
t_{event}	=	Duration of a single event (hr/event)
π	=	Pi (dimensionless)
t*	=	Time to reach steady state (hr)
B	=	Octanol water partition coefficient divided by 10^4 (dimensionless)
CF_3	=	Units conversion factor ($mg/10^3\ \mu g$)
CF_4	=	Units conversion factor ($liter/10^3\ cm^3$)
CF_5	=	Units conversion factor ($mg/10^3\ \mu g$)
CF_6	=	Units conversion factor ($liter/10^3\ cm^3$)

For a given compound, the values for B, PC, T, and t^* can be found in Table 5-8 of the dermal guidance document (USEPA, 1992d).

Once the dose per event (DA_{event}) is calculated, the dermally absorbed dose (DAD) for use in risk calculations can be derived. Dermally absorbed dose for use in risk calculations is derived generally (for adults who are no longer growing) as follows:

$$\text{Intake-Dermal} = DA_{event}\ EV\ EF\ ED\ SA\ /\ BW\ AT$$

For children, to account for changing surface areas and bodyweights, the dermally absorbed dose is calculated as follows:

$$\text{Intake-Dermal} = (DA_{event}\ EV\ EF\ /\ AT) \sum_{i=m}^{n} (SA_i\ ED_i\ /\ BW_i)$$

where:

Intake-Dermal	=	Dermally absorbed dose (mg/kg-day)
DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
EV	=	Event frequency (events/day)
EF	=	Exposure frequency (days/year)

AT	=	Averaging time (days). For noncarcinogenic effects, AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days.
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Bodyweight at age i (kg)

For showering, 50^{th} percentile values for whole body surface area are used to represent the skin surface area available for contact with water; these values were extracted from Table 8-4 in the dermal guidance document. Estimated bodyweights are average weights, as reported in the USEPA Exposure Factors Handbook (Table 5-3).

Values of:

$$\sum_{i=m}^{n} (SA_i\ ED_i\ /\ BW_i)$$

for the age ranges of receptors at the Fort Devens 1A Sites (as calculated in Table V-1) are as follows:

AGE RANGE	DURATION OF EXPOSURE TO WATER	SUM OF AREA/DURATION/BODY WEIGHT TERMS AVERAGE CASE cm^2-yr/kg
1 to 6	5 yrs	2247.5
1 through 30	30 yrs	9302.7

ABSORBED DOSE CALCULATION - DERMAL EXPOSURE TO SOIL

The absorbed dose is calculated following the recommendations and methods described in Chapter 6 of the dermal guidance document. The calculation of the estimated dermally absorbed dose per unit area per event is:

$$DA_{event} = CS\ AF\ ABS_d\ CF$$

where:

DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
CS	=	Contaminant concentration in soil (mg/kg)
AF	=	Adherence factor of soil to skin (mg/cm^2-event)
ABS_d	=	Absorption fraction (dimensionless)
CF	=	Units conversion factor (10^{-6} kg/mg)

Dermally absorbed dose for use in risk calculations is derived generally (for adults who are no longer growing) as follows:

$$\text{Intake-Dermal} = DA_{event}\ EF\ ED\ SA\ /\ BW\ AT$$

For children, to account for changing surface areas and body weights, the dermally absorbed dose is calculated as follows:

$$\text{Intake-Dermal} = (DA_{event}\ EF\ /\ AT) \sum_{i=m}^{n} (SA_i\ ED_i\ /\ BW_i)$$

where:

Intake-Dermal	=	Dermally absorbed dose (mg/kg-day)
DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
EF	=	Exposure frequency (events/year)
AT	=	Averaging time (days). For noncarcinogenic effects, AT = ED, and for carcinogenic effects AT = 70 years or 25,550 days.
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Bodyweight at age i (kg)

For the typical case, USEPA recommends SA for head and hands only and for the "reasonable worst case" the SA of the head, hands, forearms, and lower legs as the SA available for contact with soil. EPA simplifies these assumptions by saying that 25% of the total body surface area would be available for soil contact. For children between 6 and 16 years of age, the population potentially exposed to sediment at Shepley's Hill and Cold Spring Brook Landfills, the default values for each age group are set equal to 25% of the 50^{th} percentile whole body SA values. Estimated bodyweights are the average of the 50^{th} percentile female and male weights. These values are shown in the attached spreadsheet.

The value of

$$\sum_{i=m}^{n} (SA_i \; ED_i \; / \; BW_i)$$

for the age range of the receptors at Fort Devens (as calculated in Table V-1) is as follows:

AGE RANGE	DURATION OF EXPOSURE TO SEDIMENT	SUM OF AREA/DURATION/ BODY WEIGHT TERMS AVERAGE CASE cm^2-yr/kg
6 to 16	10 yrs	848.6

Table V–1 -- Exposure parameters for dermal contact

	AVAILABLE FOR WATER CONTACT	AVAILABLE FOR SOIL CONTACT					
AGE	50%ILE WHOLE BODY SA (1) CM SQ	25% x 50%ILE BODY SA CM SQ	50%ILE (2) BODYWEIGHT KG MALE	50%ILE (2) BODYWEIGHT KG FEMALE	EST 50%ILE BODYWEIGHT AVG OF M/F KG	(EDi X SAi)/BWi AVG CASE WATER	(EDi X SAi)/BWi AVG CASE SEDIMENT
	AVG	AVG				AVG	AVG
1 < 2 (3)	5398	1350	11.5	10.5	11	490.7	122.7
2 < 3	6030	1508	13.4	12.6	13	463.8	116.0
3 < 4	6640	1660	15.3	14.6	14.95	444.1	111.0
4 < 5	7310	1828	17.4	16.4	16.9	432.5	108.1
5 < 6	7930	1983	19.3	18.8	19.05	416.3	104.1
6 < 7	8660	2165	21.9	21	21.45	403.7	100.9
7 < 8	9360	2340	24.4	23.5	23.95	390.8	97.7
8 < 9	10000	2500	27.3	27.3	27.3	366.3	91.6
9 < 10	10700	2675	29.7	29.6	29.65	360.9	90.2
10 < 11	11800	2950	34.5	34.3	34.4	343.0	85.8
11 < 12	12300	3075	36.4	40	38.2	322.0	80.5
12 < 13	13400	3350	42.1	45.2	43.65	307.0	76.7
13 < 14	14700	3675	47.7	48.6	48.15	305.3	76.3
14 < 15	16100	4025	55.5	52.8	54.15	297.3	74.3
15 < 16	17000	4250	60.2	53.9	57.05	298.0	74.5
16 < 17	17600	NA	63.6	55.3	59.45	296.0	NA
17 < 18	18000	NA	65.7	58.3	62	290.3	NA
18 < 75	19400	NA	75.9	61.5	70	277.1	NA
				CHILD: 5 YRS	AGE 1 < 6 SUM	2247.5	561.9
				CHILD: 10 YRS	AGE 6 < 16 SUM	3394.3	848.6
				CHILD/ADULT: 30 YRS	AGE 1 < 31	9302.7	NA

(1) DERMAL EXPOSURE ASSESSMENT: PRINCIPLES AND APPLICATIONS, INTERIM REPORT
(2) EXPOSURE FACTORS HANDBOOK TABLE 5–3
(3) SAs BASED ON EQUATION SA = K X BW^2/3. K CALCULATED FROM AGE 2–3 DATA

CALCULATION OF PERMEABILITY CONSTANTS PER EVENT

TABLE W-1
CALCULATION OF PERMEABILITY CONSTANTS PER EVENT
SHEPLEY'S HILL LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

SHPCevent | 14-Dec-93

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
Permeability per Event	PC_{event}	chemical specific	cm/event	
Permeability Constant	PC	chemical specific	cm/hr	USEPA, 1992d
Duration of a Single Event	t_{event}	0.2	hr	
Thickness of Stratum Corneum	L_{sc}	10	um	USEPA, 1992d
Octanol-water Partition Coefficient/10^4	B	chemical specific	dimensionless	USEPA, 1992d
Pi	Pi	3.14	dimensionless	USEPA, 1992d
	T	$L_{sc}^2/6D_{sc}$	hr	USEPA, 1992d
Time to Reach Steady-State	t^*	chemical specific	hr	USEPA, 1992d
Stratum Corneum Diffusion Coefficient	D_{sc}	chemical specific	cm^2/hr	USEPA, 1992d

EQUATIONS

INORGANICS

$$PC_{event} = PC \times t_{event}$$

ORGANICS

$$PC_{event} = 2PC \times (6T \times t_{event}/Pi)^{0.5}$$

Where $t_{event} < t^*$

and: $$PC_{event} = PC \times ((t_{event}/(1+B)) + (2T \times ((1+3B)/(1+B))))$$

Where $t_{event} > t^*$

REFERENCES

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

TABLE W-1
CALCULATION OF PERMEABILITY CONSTANTS PER EVENT
SHEPLEY'S HILL LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

COMPOUND	PC (cm/hr)	T (hr)	t^* (hr)	B (unitless)	PC_{event} (cm/event)
ORGANICS					
Benzene	1.1E-01	2.6E-01	6.3E-01	1.3E-02	6.93E-02
Chloroethane	8.0E-03	2.2E-01	5.2E-01	2.7E-03	5.13E-03
Dichlorobenzenes (1)	8.7E-02	6.9E-01	4.1E+00	4.0E-01	8.94E-02
1,1-Dichloroethane	8.9E-03	3.5E-01	8.4E-01	6.2E-03	6.51E-03
1,2-Dichloroethane	5.0E-03	3.5E-01	8.4E-01	3.0E-03	3.66E-03
1,2-Dichloroethene (total)	1.0E-02	3.4E-01	8.2E-01	7.2E-03	8.88E-03
1,2-Dichloropropane	1.0E-02	4.3E-01	1.0E+00	1.0E-02	8.11E-03
Trichlorofluoromethane	1.7E-02	6.0E-01	1.4E+00	3.4E-02	1.63E-02
INORGANICS					
Aluminum	1.0E-03	-	-	-	2.00E-04
Antimony	1.0E-03	-	-	-	2.00E-04
Arsenic	1.0E-03	-	-	-	2.00E-04
Barium	1.0E-03	-	-	-	2.00E-04
Calcium	1.0E-03	-	-	-	2.00E-04
Chromium	1.0E-03	-	-	-	2.00E-04
Cobalt	1.0E-03	-	-	-	2.00E-04
Copper	1.0E-03	-	-	-	2.00E-04
Iron	1.0E-03	-	-	-	2.00E-04
Lead	1.0E-03	-	-	-	2.00E-04
Magnesium	1.0E-03	-	-	-	2.00E-04
Manganese	1.0E-03	-	-	-	2.00E-04
Nickel	1.0E-03	-	-	-	2.00E-04
Potassium	1.0E-03	-	-	-	2.00E-04
Sodium	1.0E-03	-	-	-	2.00E-04
Vanadium	1.0E-03	-	-	-	2.00E-04
Zinc	1.0E-03	-	-	-	2.00E-04

(1) Values for 1,3-dichlorobenzene used as surrogates for dichlorobenzenes.

TABLE W-2
CALCULATION OF PERMEABILITY CONSTANTS PER EVENT
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

CSBPCevent | 14-Dec-93

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
Permeability per Event	PC_{event}	chemical specific	cm/event	
Permeability Constant	PC	chemical specific	cm/hr	USEPA, 1992d
Duration of a Single Event	t_{event}	0.2	hr	
Thickness of Stratum Corneum	L_{sc}	10	um	USEPA, 1992d
Octanol-water Partition Coefficient/10^4	B	chemical specific	dimensionless	USEPA, 1992d
Pi	Pi	3.14	dimensionless	USEPA, 1992d
	T	$L_{sc}^2/6D_{sc}$	hr	USEPA, 1992d
Time to Reach Steady-State	t^*	chemical specific	hr	USEPA, 1992d
Stratum Corneum Diffusion Coefficient	D_{sc}	chemical specific	cm^2/hr	USEPA, 1992d

EQUATIONS

INORGANICS

$$PC_{event} = PC \times t_{event}$$

ORGANICS

$$PC_{event} = 2PC \times (6T \times t_{event}/Pi)^{0.5}$$

Where $t_{event} < t^*$

and: $$PC_{event} = PC \times ((t_{event}/(1+B)) + (2T \times ((1+3B)/(1+B))))$$

Where $t_{event} > t^*$

REFERENCES

USEPA, 1992d. Dermal Exposure Assessment: Principles and Applications.

TABLE W-2
CALCULATION OF PERMEABILITY CONSTANTS PER EVENT
COLD SPRING BROOK LANDFILL
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

COMPOUND	PC (cm/hr)	T (hr)	t^* (hr)	B (unitless)	PC_{event} (cm/event)
ORGANICS					
bis(2-ethylhexylphthalate)	3.3E-02	2.1E+01	1.0E+02	1.3E+01	1.87E-01
INORGANICS					
Aluminum	1.0E-03	-	-	-	2.00E-04
Arsenic	1.0E-03	-	-	-	2.00E-04
Barium	1.0E-03	-	-	-	2.00E-04
Calcium	1.0E-03	-	-	-	2.00E-04
Chromium	1.0E-03	-	-	-	2.00E-04
Cobalt	1.0E-03	-	-	-	2.00E-04
Copper	1.0E-03	-	-	-	2.00E-04
Iron	1.0E-03	-	-	-	2.00E-04
Lead	1.0E-03	-	-	-	2.00E-04
Magnesium	1.0E-03	-	-	-	2.00E-04
Manganese	1.0E-03	-	-	-	2.00E-04
Nickel	1.0E-03	-	-	-	2.00E-04
Potassium	1.0E-03	-	-	-	2.00E-04
Selenium	1.0E-03	-	-	-	2.00E-04
Sodium	1.0E-03	-	-	-	2.00E-04
Vanadium	1.0E-03	-	-	-	2.00E-04
Zinc	1.0E-03	-	-	-	2.00E-04

NONACOICUS BROOK AREA PRELIMINARY RISK EVALUATION

APPENDIX X
NONACOICUS BROOK AREA
PRELIMINARY RISK EVALUATION

1.0 Preliminary Risk Evaluations

This section contains Public Health and Ecological Preliminary Risk Evaluations (PREs) for Nonacoicus Brook area shallow groundwater and soil. These PREs are based on the analytical data compiled in the RI Addendum Report for the Group 1A sites. The PREs are screening-level evaluations of potential risks that environmental contaminants may pose to human and ecological receptors in the area of Nonacoicus Brook.

1.1 Introduction

The PRE Methodology has been described in detail in previous Fort Devens Site Investigation (SI) Reports for the Groups 3, 5, and 6 Study Areas (ABB-ES, 1993a) and the Groups 2, 7, and Historic Gas Stations Study Areas (ABB-ES, 1993b). An abbreviated summary of the methodology used for the Public Health and the Ecological PREs follows in Subsections 1.2 and 1.3.

Shallow groundwater and surface soil samples collected in the vicinity of the Nonacoicus Brook area (Figure X-1) were analyzed for parameters that could be indicative of environmental medium contamination. These analytical data, presented in Tables 4-14 and 4-15 of the RI Addendum Report, were used in this PRE. The analytical data were compared to established Fort Devens analyte background concentrations when background data were available. The methodology used to calculate analyte background concentrations is provided in Section 4.0. Analytes which exceeded background concentrations were considered contaminants which could pose potential risk to ecological and human receptors. Therefore, these analytes were retained for comparison to human health and ecological guidelines.

1.2 Public Health PRE

For the Public Health PRE, the analytical data were compared to readily available public health guidelines for soil and groundwater. Soil guidelines used

in this PRE are contained in the USEPA Region III Risk-Based Concentration Table, Fourth Quarter 1993 (Smith, 1993) and the Massachusetts Department of Environmental Protection (MADEP) Massachusetts Contingency Plan (MADEP, 1993). Groundwater guidelines are contained in the USEPA Drinking Water Regulations and Health Advisories (USEPA, 1993); the Massachusetts Drinking Water Standards and Guidelines (West, 1993); and the USEPA Region III Risk-Based Concentration Table, Fourth Quarter 1993 (Smith, 1993).

The Region III Risk-Based Concentration Table is used by USEPA Region III toxicologists as a risk-based screening tool for Superfund sites, and as a benchmark for evaluating preliminary site investigation data and preliminary remediation goals. Although it has no official status either as regulation or guidance, it is useful as a screening tool. The risk-based concentrations are based on toxicity constants and "standard" exposure scenarios and they correspond to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1, or lifetime cancer risk of $1x10^{-6}$, whichever occurs at a lower concentration) in water, air, fish tissue, and soil. The MADEP MCP soil guidelines are intended to represent soil concentrations of hazardous materials that would allow the attainment of a permanent solution at a disposal site. These guidelines are based on either a risk-based soil concentration, the practical quantitation limit of the contaminant, or the background concentration of the contaminant, and are derived via methodology described in MADEP's draft regulations (MADEP, 1993a).

For soil, Region III risk-based concentrations have been developed for commercial/industrial soil exposure and residential soil exposure. The commercial/industrial concentrations are based on an assumption that a worker ingests soil 250 days per year for 25 years, at an ingestion rate of 100 milligrams per day (mg/day). The residential concentrations are based on an assumption that children 1 to 6 years of age ingest 200 milligrams of soil per day, 350 days per year, for 6 years, and that residents 7 to 30 years of age ingest 100 milligrams of soil per day, 350 days per year, for 24 years. Residential risk-based soil concentrations for non-carcinogens are based on childhood exposure and, for carcinogens, are based on combined childhood and adult exposure. MADEP MCP soil guidelines have been developed for three soil types, each of which represents different exposure/use assumptions. Soil category S-1 standards represent soil concentrations designed to protect sensitive receptors (e.g., children) from exposure to easily accessible soil (e.g., surface soil). Soil categories S-2 and S-3 standards represent soil concentrations designed to protect less-

sensitive receptors (e.g., adults, utility workers) from exposure to surface and subsurface soils. The S-1 soil standards are used in this PRE and represent the most conservative or health-protective standards.

Nonacoicus Brook area shallow groundwater contaminant concentrations were compared to criteria chosen preferentially from (1) USEPA Drinking Water Regulations; (2) Massachusetts Drinking Water Standards and Guidelines; and (3) USEPA Region III Risk-based Concentration Table, Fourth Quarter.

USEPA Drinking Water Regulations are issued as the Maximum Contaminant Level (MCL), which is the maximum allowable contaminant concentration in tap water (USEPA, 1993). Both final and proposed guidelines were used for comparison to study area analytical data. Massachusetts Drinking Water Standards and Guidelines have been promulgated by MADEP (West, 1993). For some contaminants, guidelines are more stringent than the federal standards. Additionally, MADEP has developed drinking water guidelines for contaminants for which no federal standards exist. Risk-based concentrations in the USEPA Region III table are based on combined child and adult exposure and the assumption that a resident will consume 2 liters of water per day, 350 days per year, for 30 years.

Future use of land in the area of Nonacoicus Brook is undetermined at this time. The area is a forested area which routinely floods and has a shallow groundwater table. It is therefore unlikely that the land would have commercial/industrial or residential use in the future. However, because the exposure assumptions associated with residential use are more conservative than those associated with commercial/industrial use, the Region III residential soil risk-based concentrations are used for comparison to the analytical data in this study area. Similarly, MADEP MCP S-1/GW-1 soil guidelines (MADEP, 1993) were used for comparison to the analytical data because they are designed to protect the most sensitive receptors (e.g., residential children) under conditions of the most frequent soil use and contact.

The Region III table does not include lead, an analyte present in Nonacoicus Brook area soil. However, the USEPA has published an interim soil cleanup level for total lead which is protective for direct contact exposure in residential settings (USEPA, 1989). This interim cleanup level is used in the Public Health PRE.

1.3 Ecological PRE

The Ecological PRE includes a preliminary ecological characterization of the Nonacoicus Brook area and a comparison of the analytical data to ecological PCLs estimated for this appendix. The purpose of the ecological characterization is to identify ecological receptors potentially exposed to contamination identified in this study area. A brief description of the vegetative cover in the vicinity of Nonacoicus Brook is provided along with identification of potential faunal receptors. The evaluation of exposure to ecological receptors was conducted through comparison of the concentrations of detected analytes to Protective Contaminant Levels (PCLs). Soil PCLs were used for comparison to analytical data because (1) soil at the Nonacoicus Brook site is the primary ecological media of concern; and (2) no state or federal ecological-based standards, guidelines, or threshold criteria exist for surface soil exposure.

Nonacoicus Brook soil PCLs were derived through a computer-generated chronic exposure food web model, as described in detail in Appendix H of the SI Report for Groups 2, 7, and Historic Gas Stations Study Areas (ABB-ES, 1993b); the chronic exposure food web model differs only in the site area used in the PCL calculations and the ecological receptors chosen for the food web. In order to better reflect actual site conditions, the Nonacoicus Brook site area (1.8 acres) was used in the PCL calculations, rather than the value (0.5 acres) chosen for Groups 2, 7 and Historic Gas Stations Study Areas PCL calculations (ABB-ES, 1993b). Because the primary habitat in the vicinity of Nonacoicus Brook is a forested region, PCLs for Nonacoicus Brook soil were developed for the following ecological receptors, whose life-history requirements (detailed in Section 7.0 of the RI Addendum Report) are summarized below:

- Short-tailed Shrew (*Blarina brevicauda*). The preferred habitat of this carnivorous small mammal includes woody regions with moist conditions. The shrew's small body size, limited home range, and voracious appetite are factors which tend to maximize potential contaminant uptake. This receptor has been used to represent the primary and secondary consumer small mammal community in the food web model.

- American woodcock (*Scolopax minor*). This small bird is often found in forested wetlands and forages primarily on invertebrates

such as earthworms, crickets, and beetles; plant consumption varies seasonally. The American woodcock was used to represent the small avian receptor trophic level for the food web model. This receptor was added to the existing list of Group 1A avian receptors (osprey, mallard duck, and great blue heron) because its life history habitat requirements (summarized in Attachment A, Table A-1) better match the wooded habitat in the area of Nonacoicus Brook. Additionally, the American woodcock is known to occur in Fort Devens habitats similar to the one in the vicinity of Nonacoicus Brook.

- Green frog (*Rana clamitans*). This receptor is typically found in shallow waters, brooks, and swamps, and forages on shoreline vegetation, small fish, and insects. The green frog has been used to represent the amphibian community in the food web model.

- Raccoon (*Procyon lotor*). The habitat and diet of this mammal are varied, as it is known to inhabit woodlands, agricultural fields, and floodplains, and forage for crayfish, insects, vegetation, fruits, and garbage. The raccoon has been used to represent the omnivorous mammal community in the food web model.

2.0 Public Health PRE

The purpose of the public health PRE is to provide a screening-level evaluation of actual and potential risks to humans if exposed to contaminants detected in the samples collected in the Nonacoicus Brook area. For this PRE, the future use of the Nonacoicus Brook area is assumed to be residential. As previously stated, it is unlikely that land in this area would have commercial/industrial or residential use in the future. In fact, it is likely that use of the Nonacoicus Brook area for these purposes is prohibited under the Massachusetts Floodplain Protection Act (MGL 131.40 and 310.10 CMR). The use of the residential soil screening criteria and drinking water standards represents the most conservative (i.e., health protective) approach. Tables X-1 and X-2 present summary statistics and human health guidelines used in the PRE.

2.1 Shallow Groundwater

Four groundwater samples (SHW-92-01X-through-SHW-92-04X) were collected from shallow, 2.5-to-3-foot deep pits in the study area and analyzed for PAL VOCs, pesticides, PCBs, and inorganics (Figure X-1). Due to the high TSS, both unfiltered and filtered samples were analyzed. A discussion of sample collection and analysis is presented in Section 4.0 of the RI Addendum Report; analytical data for each sample collected are provided in Table 4-14 of Report. Inorganics were the only analytes identified in the shallow groundwater samples; Table X-1 presents summary statistics and a comparison to screening guidelines. In unfiltered samples, all but the maximum detected concentration of sodium exceeded Fort Devens background concentrations. In filtered samples, the maximum concentrations of six analytes exceeded Fort Devens background concentrations. Chromium, copper, mercury, and vanadium were not identified in filtered samples.

The maximum detected concentrations of aluminum, iron, lead and manganese in unfiltered water, and the maximum detected concentrations of aluminum, iron, and manganese in filtered water, exceeded their respective drinking water standards or guidelines. The exceedances for three analytes (aluminum, iron, and manganese) involve secondary MCLs. Secondary MCLs are federal standards promulgated for aesthetic or economic reasons, not health reasons. Although an MCL does not exist for manganese at this time, the maximum concentration of manganese exceeds the Maximum Contaminant Level Goal for manganese of 200 $\mu g/L$, which is a health based goal. The Fort Devens background concentrations of aluminum, iron, and manganese also exceeded the drinking water standards. Although the maximum detected concentrations of aluminum and iron in filtered groundwater exceeded their respective standards, they did not exceed their respective Fort Devens background concentrations.

2.2 Surface Soil

Table X-2 presents a comparison of maximum detected analyte concentrations of the eight surface soil samples collected in the Nonacoicus Brook area to USEPA residential soil concentrations and MADEP MCP S-1 soil guidelines, which represent the most health-protective set of soil standards developed by MADEP (MADEP, 1993). Soil data are represented by sample locations SHD-92-29X-through-SHD-92-32X (Figure X-1), each sampled at 0- and 2-foot depths (to

equal eight samples total). Analytical data for each sample collected is provided in Table 4-15 of the RI Addendum Report. Two pesticides (DDT and DDE), one volatile organic compound (trichlorofluoromethane) and twenty inorganics were identified in Nonacoicus Brook region soil (Table X-2). The maximum concentrations of all inorganics except aluminum, iron, potassium, magnesium, and vanadium exceeded Fort Devens background concentrations. The maximum concentrations of arsenic and beryllium exceeded their respective Region III residential soil concentrations. While the maximum concentration of beryllium slightly exceeded the MADEP MCP S-1/GW-1 soil guideline, the maximum detected concentration of arsenic did not exceed the S-1/GW-1 soil guideline. The maximum detected concentration of trichlorofluoromethane was well below the USEPA Region III risk-based concentration for residential soil.

3.0 Ecological PRE

The purpose of the Ecological PRE at Nonacoicus Brook is to provide a screening-level evaluation of actual and potential risks that environmental contaminants may pose to the resident and migratory ecological receptors in the Nonacoicus Brook area. As discussed in Section 4.3 of the RI Addendum Report, the shallow groundwater is not believed to be discharging to the surface soil in the Nonacoicus Brook region. Because there is little potential for ecological receptor contact with groundwater in the Nonacoicus Brook area, shallow groundwater has not been evaluated in this ecological PRE.

3.1 Ecological Habitat Characterization

The Nonacoicus Brook site area primarily consists of a forested region with a moderately thick understory. It is likely that portions of this region contain jurisdictional wetlands. A sloping hillside is located upgradient of the brook area and is dominated by white oak (*Quercus alba*), red oak (*Quercus rubra*) and white pine (*Pinus strobus*), with an understory consisting primarily of lowbush blueberry (*Vaccinium angustifolium*), sweet fern (*Comptonia peregrina*), bracken fern (*Pteridium aquilinum*), and common juniper (*Juniper communis*), interspersed with oak and pine saplings.

The tree layer in the Nonacoicus Brook forested region is dominated by red maple (*Acer rubrum*) and white oak, and is interspersed with grey birch (*Betula populifolia*), white pines and occasional large silver maple (*Acer saccharinum*).

The shrub community in this region is dominated by nannyberry (*Viburnum lentago*), highbush blueberry (*Vaccinium corymbosum*), red maple, and white pine saplings. Occasional northern arrowwood (*Viburnum recognitum*), grape (*Vitis* sp.), honeysuckle (*Lonicera* sp.), black cherry (*Prunus serotina*), wood fern (*Dryopteris* sp.), and red osier dogwood (*Cornus stolonifera*) are interspersed throughout the area. The understory within the forested area is dominated by various fern species such as royal fern (*Osmunda regalis*), sensitive fern (*Onoclea sensibilis*), and cinnamon fern (*Osmunda cinnamomea*), grass species, soft rush (*Juncus effusus*), sphagnum moss (*Sphagnum* sp.), princess pine (*Lycopodium obscurum*), wool grass (*Scirpus cyperinus*), goldenrod (*Solidago* sp.), bramble (*Rubus* sp.), and alder (*Alnus rugosa*).

Although less than two acres in size, the Nonacoicus Brook area may provide a suitable habitat for a number of terrestrial and semi-aquatic faunal species including the short-tailed shrew, mink, beaver, green frog, painted turtle, American woodcock, and white-tailed deer.

Potential contaminant exposure pathways exist in the Nonacoicus Brook area for terrestrial and semi-aquatic receptors via incidental surface soil ingestion and terrestrial food web exposure. In addition, due to the close proximity of Nonacoicus Brook to Plow Shop Pond, terrestrial and semi-terrestrial receptors associated with Plow Shop Pond may be exposed to soil contaminants in the Nonacoicus Brook area. A detailed ecological risk assessment of Plow Shop Pond is provided in Section 7.0 of the RI Addendum Report.

3.2 Surface Soil

Table X-3 presents a comparison of summary statistics on the eight surface soil samples collected in the Nonacoicus Brook area to surface soil PCLs. Soil data are represented by sample locations SHD-92-29X-through-SHD-92-32X (Figure X-1), each sampled at 0- and 2-foot depths. Analytical data for each sample collected are provided in Table 4-15 of the RI Addendum Report. Two pesticides (DDT and DDE), one volatile organic compound (trichlorofluoromethane), and twenty inorganics were identified in the Nonacoicus Brook region surface soil. The maximum detected concentrations of all inorganics except aluminum, iron, potassium, magnesium, and vanadium exceeded Fort Devens background soil concentrations. These inorganics, in addition to the essential nutrients calcium

and sodium, were not retained as COPCs and therefore were excluded from comparison to PCL values.

With the exception of lead, the maximum detected concentrations of all COPCs were well below their respective PCL values. The maximum detected concentration of lead exceeded its PCL value by a factor of approximately two (82 versus 48.2 μg/g). Uncertainties associated with use of the lead PCL value are discussed in Section 4.0 of this appendix.

4.0 SUMMARY OF PREs

Four analytes in shallow groundwater exceeded drinking water guidelines, two analytes in surface soil exceeded public health soil guidelines, and one analyte in surface soil exceeded its ecological PCL concentration.

Although four inorganics detected in shallow groundwater exceeded their respective drinking water guidelines (aluminum, iron, lead, and manganese), only the drinking water guideline for lead and the MCLG for manganese are based on health-protective endpoints. Analyte concentration exceedances of aluminum and iron guidelines, which are derived for aesthetic or economic reasons, may not be indicative of a health risk. In addition, because the groundwater was obtained from test pits at two-to-three foot depths, it is not representative of groundwater that would be used for drinking water, thereby making drinking water guidelines conservative standards for comparison.

Arsenic and beryllium both exceeded Region III risk-based soil concentrations; however, arsenic did not exceed the MADEP S-1/GW-1 standard and beryllium, which was detected in only one sample, only slightly exceeded the S-1/GW-1 standard. As previously stated, these standards are for a residential setting with soil frequently being contacted by sensitive receptors. It is likely that the Nonacoicus Brook forested area will not be used for residential (or commercial) purposes. Evaluation of Nonacoicus Brook analytical data with these guidelines represents a conservative approach.

There are numerous uncertainties and assumptions associated with the ecological PRE including: ecological receptor exposure assumptions and toxicity dose-response data used in PCL calculations; lack of quantitative evaluation of dermal

and inhalation exposure pathways, lack of consideration of additive or antagonistic effects of exposure to multiple chemicals; and, lack of evaluation of population-level risks. These uncertainties are described in more detail in Appendix H of the Groups 2, 7 and Historic Gas Stations report (ABB-ES, 1993b) and in Section 7.3 of the RI Addendum Report.

Due to these multiple uncertainties, the calculated ecological PCL for lead was below the Fort Devens established background lead concentration. Therefore, as described in ABB-ES (1993b), the lead PCL was set equal to the Fort Devens established background lead concentration.

One variable which accounts for the lower-than-background calculated lead PCL values is the bioaccumulation factor (BAF) for invertebrates (2.4) that was used in the food web model. A recent study conducted by Corp and Morgan (1991) indicates that a more appropriate invertebrate BAF value for lead may be approximately two orders of magnitude lower than the one used in the food web model. Regression equations developed by Corp and Morgan (1991) express the relationships between earthworm tissue concentrations measured in their study and soil lead concentrations, soil calcium concentrations, and soil pH. This study suggests that increased soil calcium concentrations generally result in decreased lead bioaccumulation. The Corp and Morgan regression equation is:

$$\log(\textit{tissue concentration}) = 1.16 + 0.916 \log(\textit{soil concentration}) - 0.326 \log(\textit{soil calcium concentration})$$

Using the regression equation to express earthworm tissue concentration in relation to the average Nonacoicus Brook area soil lead and calcium concentration results in a lead BAF of 0.095 (assuming 90 % dry weight to weight wet conversion). Use of this BAF as the invertebrate BAF for lead results in a calculated lead PCL of 207 mg/kg (for the shrew). Therefore, exceedance of the lead PCL (48 mg/kg) by the maximum detected surface soil lead concentration (82 mg/kg), may result in a considerable overestimate of ecological risk. Use of the invertebrate BAF value developed by the method of Corp and Morgan (1991) results in no ecological risk at the Nonacoicus Brook area.

In summary, the PREs conducted for the detected contaminants indicate some exceedances of public health standards or guidelines for soil and groundwater and one exceedance of an ecological PCL. However, these exceedances are based on comparisons of detected concentrations to conservative standards and are not considered to represent a significant public health or ecological risk.

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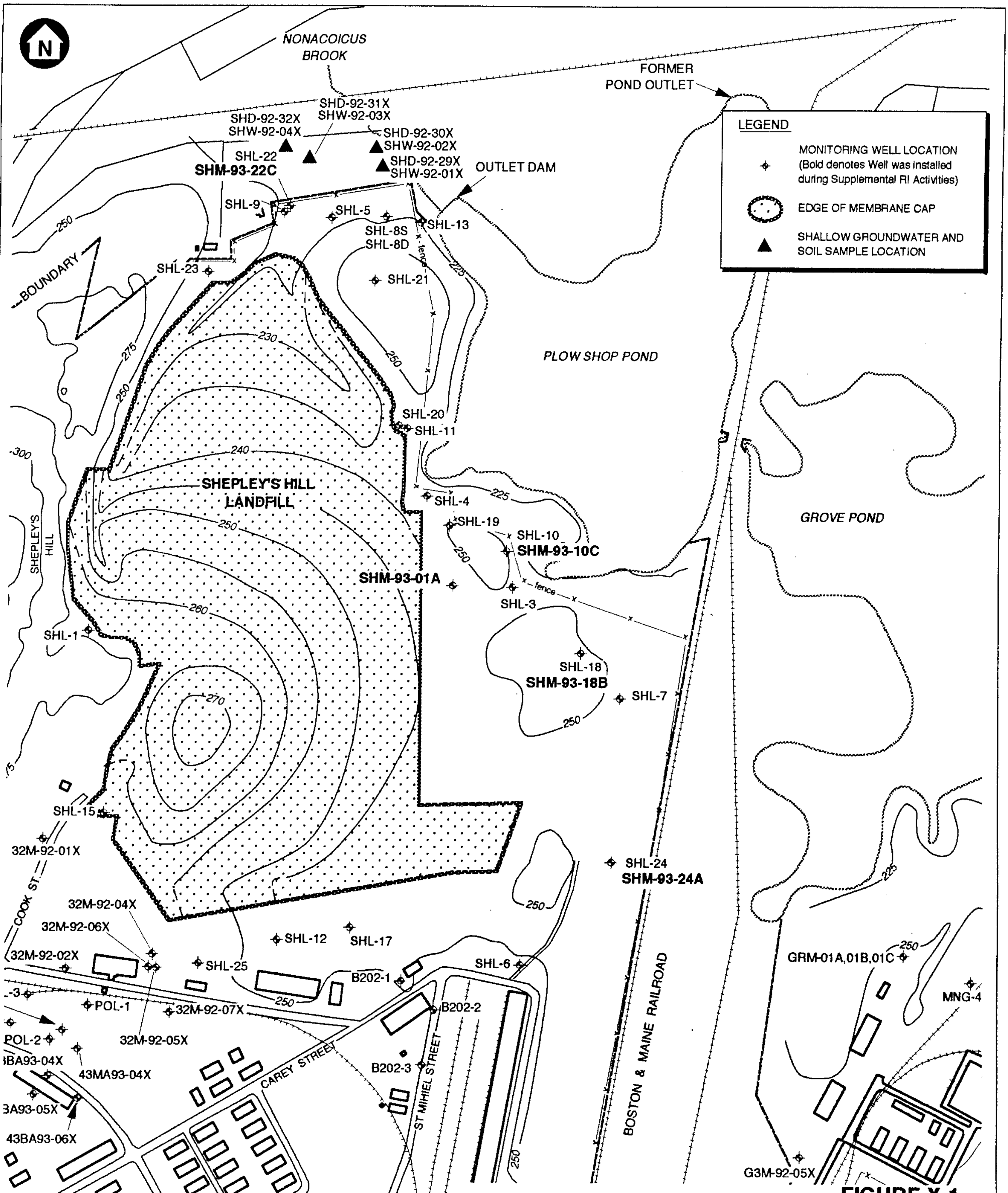

FIGURE X-1
SHALLOW GROUNDWATER AND SOIL SAMPLE LOCATIONS - NONACOICUS BROOK WETLAND
REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

SCALE IN FEET

0 500 1000

9303022D 1S6N

ABB Environmental Services, Inc.

TABLE X-1
HUMAN HEALTH PRE OF SHALLOW GROUNDWATER

NONACOICUS BROOK FLOODPLAIN AREA
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

Analyte	Groundwater Background Concentration [a] (ug/l)	Maximum Concentration Detected (ug/l)	Frequency of Detection [b]	Maximum Exceeds Exceeds Background? (Y/N)	Drinking Water Guideline (ug/l)	Maximum Exceeds Guideline Concentration? (Y/N)
Inorganics – Unfiltered						
aluminum	6870	18,800	3/4	YES	200 [c]	YES
arsenic	10.5	24.9	3/4	YES	50 [d]	NO
barium	39.6	136	4/4	YES	2,000 [d]	NO
calcium	14,700	28,300	4/4	YES	NA	NA
chromium	14.7	32.7	2/4	YES	100 [d]	NO
copper	8.09	19.0	1/4	YES	1,000 [c]	NO
iron	9,100	14,700	3/4	YES	300 [c]	YES
lead	4.25	81.7	4/4	YES	15 [e]	YES
mercury	0.243	0.886	2/4	YES	2 [d]	NO
potassium	2,370	3,440	4/4	YES	NA	NA
magnesium	3,480	3,790	4/4	YES	NA	NA
manganese	291	541	4/4	YES	50 [c]	YES
sodium	10,800	2,590	4/4	NO	20,000 [f]	NO
vanadium	11	23.9	2/4	YES	260 [g]	NO
zinc	21.1	251	2/4	YES	5,000 [c]	NO
Inorganics – Filtered						
aluminum	6,870	1,220	2/4	NO	200 [c]	YES
arsenic	10.5	2.98	1/4	NO	50 [d]	NO
barium	39.6	67	4/4	YES	2,000 [d]	NO
calcium	14,700	25,900	4/4	YES	NA	NA
iron	9,100	566	4/4	NO	300 [c]	YES
lead	4.25	5.53	2/4	YES	15 [e]	NO
potassium	2,370	2,530	4/4	YES	NA	NA
magnesium	3,480	3,410	4/4	NO	NA	NA
manganese	291	417	4/4	YES	50 [c]	YES
sodium	10,800	2,340	4/4	NO	20,000 [f]	NO
zinc	21.1	160	1/4	YES	5,000 [c]	NO

NOTES:

[a] Fort Devens background groundwater concentrations (ABB-ES, 1993b).

[b] Shallow groundwater samples include SHW-92-01X, SHW-92-02X, SHW-92-03X, and SHW-92-04X (filtered and unfiltered for each sample); analytical data presented in Table 4-11 of this report.

[c] USEPA secondary MCL (USEPA, 1993).

[d] USEPA primary MCL (USEPA, 1993).

[e] No USEPA MCL exists for this contaminant; value used is USEPA Action Level (USEPA, 1993).

[f] USEPA Drinking Water Equivalent Level guideline (USEPA, 1993).

[g] USEPA Region III risk-based concentration table — tap water, fourth quarter 1993 (Smith, 1993).

NA = not available or not applicable

TABLE X-2
HUMAN HEALTH PRE OF SOIL

NONACOICUS BROOK FLOODPLAIN AREA
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

Analyte	Soil Background Concentration [a] (ug/g)	Maximum Concentration Detected (ug/g)	Frequency of Detection [b]	Maximum Exceeds Exceeds Background? (Y/N)	Region III Residential Soil Concentration [c] (ug/g)	MADEP MCP S-1 Soil Guidelines [d] (ug/g)	Maximum Exceeds Region III Concentration? (Y/N)	Maximum Exceeds MADEP MCP Concentration? (Y/N)
Organics (ug/g)								
DDT	NA	0.042	3/8	NA	1.9	2	NO	NO
DDE	NA	0.17	3/8	NA	1.9	2	NO	NO
trichlorofluoromethane	NA	0.008	1/8	NA	23,000	NA	NO	NA
Inorganics (ug/g)								
aluminum	15,000	14,500	8/8	NO	230,000	NA	NO	NA
arsenic	21	28.0	8/8	YES	0.36	30	YES	NO
barium	42.5	55	7/8	YES	5,500	NA	NO	NA
beryllium	0.347	1.25	1/8	YES	0.15	0.4	YES	YES
calcium	1,400	2,850	8/8	YES	NA	NA	NA	NA
cobalt	NA	6.5	6/8	NA	NA	NA	NA	NA
chromium	31	89.5	8/8	YES	390 [e]	200 [e]	NO	NO
copper	8.39	17.6	8/8	YES	2,900	NA	NO	NA
iron	15,000	14,600	8/8	NO	NA	NA	NA	NA
lead	48.4	82	8/8	YES	500 [f]	300	NO	NO
mercury	0.22	1.9	6/8	YES	23	10	NO	NO
potassium	1,700	1150	8/8	NO	NA	NA	NA	NA
magnesium	5,600	3,230	8/8	NO	NA	NA	NA	NA
manganese	300	340	8/8	YES	390	NA	NO	NA
sodium	131	364	8/8	YES	NA	NA	NA	NA
nickel	14	18.7	7/8	YES	1,600	300	NO	NO
selenium	NA	0.679	2/8	NA	390	300	NO	NO
silver	0.086	1.22	1/8	YES	390	100	NO	NO
vanadium	28.7	21.7	7/8	NO	550	NA	NO	NA
zinc	35.5	77.7	7/8	YES	23,000	2,500	NO	NO

NOTES:

[a] Fort Devens background soil concentrations (ABB-ES, 1993b).

[b] Soil samples include SHD-92-29X, SHD-92-30X, SHD-92-31X, and SHD-92-32X (0 and 2 ft. intervals for each sample); analytical data presented in Table 4-12 of this report.

[c] USEPA Region III Risk-based concentration table, fourth quarter 1993 (Smith, 1993)

[d] Massachusetts MCP (MADEP, 1993)

[e] For hexavalent chromium

[f] USEPA Interim Soil Cleanup Level for Superfund sites (OSWER, 9355.4-02)

NA = not available or not applicable

TABLE X-3
ECOLOGICAL PRE OF SOIL

NONACOICUS BROOK FLOODPLAIN AREA
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

Analyte	Soil Background Concentration [a] (ug/g)	Maximum Concentration Detected (ug/g)	Frequency of Detection [b]	Maximum Exceeds Exceeds Background? (Y/N)	Ecological Benchmark [c] (ug/g)	Maximum Exceeds Benchmark Concentration? (Y/N)
Organics (ug/g)						
DDT	NA	0.042	3/8	NA	0.96	NO
DDE	NA	0.17	3/8	NA	0.96	NO
trichlorofluoromethane	NA	0.008	1/8	NA	3880	NO
Inorganics (ug/g)						
aluminum	15,000	14,500	8/8	NO	NA [d]	NA
arsenic	21	28.0	8/8	YES	44	NO
barium	42.5	55.4	7/8	YES	81	NO
beryllium	0.347	1.25	1/8	YES	1.75	NO
calcium	1,400	2,850	8/8	YES	NA [e]	NA
cobalt	NA	6.5	6/8	NA	100	NO
chromium	31	89.5	8/8	YES	154	NO
copper	8.39	17.6	8/8	YES	26	NO
iron	15,000	14,600	8/8	NO	NA [d]	NA
lead	48.4	82	8/8	YES	48.4	YES
mercury	0.22	1.9	6/8	YES	16.5	NO
potassium	1,700	1,150	8/8	NO	NA [e]	NA
magnesium	5,600	3,230	8/8	NO	NA [e]	NA
manganese	300	340	8/8	YES	2,940	NO
sodium	131	364	8/8	YES	NA [e]	NA
nickel	14	18.7	7/8	YES	41	NO
selenium	NA	0.679	2/8	NA	1.73	NO
silver	0.086	1.22	1/8	YES	144	NO
vanadium	28.7	21.7	7/8	NO	NA [d]	NA
zinc	35.5	77.7	7/8	YES	1,270	NO

NOTES:

[a] Fort Devens background soil concentrations (ABB-ES, 1993b).

[b] Soil samples include SHD-92-29X, SHD-92-30X, SHD-92-31X, and SHD-92-32X (0 and 2 ft. intervals for each sample); analytical data provided in Table 4-12 of this report.

[c] Benchmark values derived via methodology presented in Groups 2,7 and Historic Gas Stations Study Areas RI (ABB-ES, 1993b).

[d] Analyte was excluded as a COPC because the maximum detected concentration was less than the background concentration.

[e] Analyte is an essential nutrient and therefore was excluded as a COPC as described in Appendix X.

NA = not available or not applicable

ATTACHMENT A

EXPOSURE PARAMETERS FOR THE AMERICAN WOODCOCK

TABLE A-1
EXPOSURE PARAMETERS FOR THE AMERICAN WOODCOCK

RECEPTOR SPECIES	EXPOSURE PARAMETER	REPORTED VALUES	REFERENCE	VALUES SELECTED FOR ECOLOGICAL RISK
American Woodcock (Scolopax minor)	Home Range (acres)	0.25 to 100 acres territory size	DeGraaf and Rudis, 1986	50 [a]
	Percent Prey Items	50 to 90 % earthworms; rest is beetles, flies, insects, and occasionally plants	DeGraaf and Rudis, 1986	Invertebrates: 85% Plants: 10% Soil: 5%
		60% earthworms, 30% insects, 10% plants shrews, rabbits, some small birds, caterpillars of large moths, grasshoppers, crickets, beetles, *dragonflies*, *ants*, *spiders*, crayfishes, earthworms, etc. The percentage of plant material in diet varies seasonally as shown below:	Martin et al., 1951	
Ingestion Rate (kg/day)		100% of body weight/day or more	Terres, 1987	0.22 kg/day
Body Weight (kg)		Males average 6.2 oz (0.18 kg); females average 7.7 oz (0.22 kg)	Terres, 1987	0.22 kg

Season	No. Months	Percent
Winter	5	9%
Spring	2	13%
Summer	3	2%
Fall	2	6%
Estimated Year-round Average		7%

[a] Average of range of values.

EVALUATION OF GROUNDWATER IRRIGATION EXPOSURE PATHWAY

EVALUATION OF GROUNDWATER IRRIGATION EXPOSURE PATHWAY

One of the comments made by the Massachusetts Department of Environmental Protection (MADEP) on the Draft Supplemental Risk Assessments for Shepley's Hill Landfill and Cold Spring Brook Landfill (July 1993) questioned the relative contribution of the exposure pathway involving the irrigation of fruits and vegetables with contaminated groundwater to the total groundwater risks. In the July 1993 draft risk assessments, this pathway was not evaluated. This was because the health risks associated with this pathway (as estimated in the RI Risk Assessment of April 1993) represented approximately one to three percent of the total risk from groundwater exposures. In addition, confidence in the risk estimates generated for the other three groundwater exposure pathways was considered much higher than for the irrigation pathway.

In response to MADEP's comment, ABB-ES performed an independent evaluation of the potential for exposure to contaminants as a result of consumption of produce that has been watered with contaminated groundwater.

The analytical data from Well Group 1 at Shepley's Hill Landfill (as summarized in Table 6-5) were used in this evaluation. Only volatile organic compounds and inorganics were detected in groundwater. Consistent with MADEP risk assessment guidance (MADEP, 1992), volatile organics were not evaluated here because significant levels of these compounds are not expected to accumulate in plants due to their volatile characteristics. To estimate concentrations of inorganic contaminants that would occur in soil as a result of irrigation with contaminated groundwater, an approach developed by the California EPA and presented in their document <u>CalTOX, A Multimedia Total Exposure Model for Hazardous Waste Sites</u> (CalEPA, 1993) was used. The CalTOX approach uses the following factors:

$$C_s = f^w{}_q \times K_D \times f_{ir} \times C_{gw}$$

Where:

C^s = concentration in soil (mg/kg)

f^{w}_{q}	=	fraction of water needs provided by groundwater (unitless) = 0.8 (CalEPA, 1993)
K_D	=	soil/soil-water partition coefficient (kg water/kg solids)
f_{ir}	=	fraction of the chemical concentration in irrigation water retained in soil water (unitless) = 0.25 (CalEPA, 1993)
C_{gw}	=	concentration in groundwater (mg/l)

Values for K_D were obtained from Baes et al. (1984), A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture.

Once a concentration in soil was obtained, the Food Chain Multipliers listed in the Short Form Documentation (MADEP, 1992) were used, in concert with appropriate dose/response values, to estimate hazard indices (HIs) and excess lifetime cancer risks (ELCRs). For those inorganics that MADEP has not developed a food chain multiplier, the highest multiplier listed by MADEP (for silver) was used as a default value. While this assumption adds additional uncertainty to this assessment, it is unlikely that it results in a significant underestimate of risk. This is because it is likely that the inorganics behave in a somewhat similar manner, as evidenced by the food chain multipliers for all the metals evaluated by MADEP (except silver, which is the highest) being within about two orders of magnitude of each other.

Using this approach, the total HI for maximum groundwater concentrations was estimated at 0.2. The ELCR associated with arsenic exposure (the only carcinogen) was 1.9×10^{-6}. In comparison, the total HI for exposure to groundwater via ingestion and while showering was estimated to be 90, while the ELCR was 8×10^{-3}. Thus, this brief analysis confirms the assertion that the produce irrigation pathway is not an important contributor to the risk estimates for groundwater exposure. Using this approach, the irrigation pathway represents about 0.2 and 0.02 percent of the noncancer and cancer risk estimates from exposure to groundwater at the maximum detected concentrations.

References

Baes, C.F. et al. 1984. "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture". Oak Ridge National Laboratory, ORNL-5786. September 1984.

California Environmental Protection Agency (CalEPA, 1993. "CalTOX, A Multimedia Total Exposure Model for Hazardous Waste Sites"; Office of Toxic Substances Control, California Environmental Protection Agency; Sacramento, California; June 1993.

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

TABLE Y-1
ESTIMATION OF HEALTH RISK FOR GROUNDWATER IRRIGATION PATHWAY
USING CALTOX MODEL AND MADEP FOOD CHAIN MULTIPLIERS

REMEDIAL INVESTIGATION ADDENDUM REPORT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

ANALYTE	CONC GW (mg/l)	Kd	CONC SOIL (mg/kg)	HIM (1/day)	RfD (mg/kg/day)	HI
NONCARCINOGENS						
Aluminum	75.5000	1500	22650.00	**5.5E-05**	NA	
Antimony	0.0033	45	0.03	**5.5E-05**	0.0004	0.00408375
Arsenic	0.3900	200	15.60	2.6E-07	0.0003	0.01352
Barium	0.3500	60	4.20	**5.5E-05**	0.07	0.0033
Chromium	0.1150	850	19.55	6.8E-06	0.005	0.026588
Copper	0.0922	35	0.65	**5.5E-05**	NA	
Lead	0.0668	900	12.02	3.4E-07	NA	
Manganese	9.6500	65	125.45	**5.5E-05**	0.14	0.04928392
Nickel	0.1770	150	5.31	9.5E-06	0.02	0.00252225
Vanadium	0.0791	1000	15.82	**5.5E-05**	0.007	0.1243
Zinc	0.2200	40	1.76	4.3E-06	0.3	0.00002522
					TOTAL	0.22362315
ANALYTE	**CONC GW (mg/l)**	**Kd**	**CONC SOIL (mg/kg)**	**CRM**	**SLOPE FACTOR**	**ELCR**
CARCINOGENS						
Arsenic	0.3900	200.00	15.60	7.00E-08	1.75	1.91E-06
					TOTAL	1.91E-06

Notes:
HIM = Chronic Hazard Index Multiplier (l/day); values extracted from Table 8-23 of MADEP,199?
Values in bold are set at the default value for silver.
CRM = Cancer Risk Multiplier (l/day); values extracted from Table 8-23 of MADEP, 1992.
HI = (HIM x CONC. SOIL)/RfD
ELCR = CRM x CONC. SOIL x Slope Factor
NA = Not available

TOXICITY PROFILES

TOXICITY PROFILES

Aluminum

Aluminum is the third most abundant element in the earth's crust, and it is ubiquitous in air and water, as well as soil. High soil concentrations are associated with industries, which burn coal and aluminum mining and smelting. Speculation exists that aluminum may be an essential nutrient. Human exposures to aluminum occur primarily through ingestion of foods grown in soil that contains aluminum, ingestion of water used in food preparation, food additives, contamination by aluminum utensils and containers and use of antacids, antiperspirants, and other drug store items. Daily aluminum intake from food and water is estimated at 2-25 mg.

Aluminum is poorly absorbed from the gastrointestinal tract. However, humans and animals accumulate excess levels of aluminum in tissues following continued exposure. Aluminum may accumulate in all tissues, with bone and lung tissue generally having the highest concentrations and blood having the lowest concentrations. Excretion occurs through urine and feces.

Many of the toxic effects of aluminum are due to its interactions with nutrients, such as phosphorus, calcium, fluoride, magnesium, iron, and Vitamin D. Aluminum toxicity is documented to occur following infusion of aluminum-contaminated dialysate fluids and parenteral nutrition solutions as well as by ingestion of aluminum-containing pharmaceutical products. Aluminum in antiperspirants can cause skin rashes in some people. Factory workers who inhale large amounts of aluminum dust may develop lung problems, such as pulmonary fibrosis. Aluminum exposure has caused lower birth weights in some animals. Studies have shown that aluminum accumulates in the brains of individuals with Alzheimer's disease. However, any causal link between aluminum exposure and this disease is yet to be demonstrated. Both human epidemiological studies and animal experiments strongly suggests that aluminum is not a carcinogen.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1989. "Toxicological Profile for Aluminum"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, October 1989.

Greger, J.L., 1993. Aluminum Metabolism. Annu. Rev. Nutr. 13: 43-63.

Antimony

Antimony may have a tri- or pentavalence and it belongs to the same periodic group as arsenic. Antimony enters the environment during the mining and processing of its ores and other related compounds. Small amounts of antimony are also released into the environment by incinerators and coal burning power plants. Antimony will strongly adhere to soil which contains iron, manganese, or aluminum. Exposure for the general population is largely from food.

The absorption and distribution of antimony within the body is thought to resemble that of arsenic. Absorption is slow and incomplete with accompanying gastrointestinal irritation when elevated levels are consumed. Trivalent antimony compounds concentrate in red blood cells and liver while pentavalent forms concentrate mostly in plasma. Excretion occurs through urine and feces.

Antimony was used for medicinal purposes to treat individuals infected with parasites. Chronic exposure to airborne antimony may cause eye, skin, and lung irritation. Chronic occupational exposures are associated with transient skin eruptions termed "antimony spots". High level oral exposures have been linked with heart problems, and severe vomiting with diarrhea. The oral RfD is based on an oral drinking water study in rats which showed changes in glucose and cholesterol metabolism. Antimony has not been evaluated by the USEPA for evidence of human carcinogenic potential. Oral feeding of antimony to rats has not produced evidence of tumorigenicity. However, in vitro mutagenicity tests have demonstrated a possible link of antimony to chromosome defects.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1991. "Toxicological Profile for Antimony"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, February 1991.

Goyer, R.A., 1991. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Eds. C.D. Klaassen, M.O. Amdur and J. Doull. Macmillan Publishing Co. N.Y.

Integrated Risk Information System (IRIS), 1993. United States Environmental Protection Agency.

Benzo(a)anthracene

Benzo(a)anthracene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also manmade. Benzo(a)anthracene occurs naturally in coal tar, crude oil, and is formed from incomplete combustion of organic material. It is also product of pyrolysis in tobacco smoke.

Benzo(a)anthracene has produced skin tumors in laboratory animals after dermal application. Benzo(a)anthracene produced mutations in bacteria and in mammalian cells, and transformed mammalian cells in culture. Although there are no human data that specifically link exposure to benzo(a)anthracene to human cancers, benzo(a)anthracene is a component of mixtures that have been associated with human cancer. As such, benzo(a)anthracene has been classified by USEPA as a B2, probable human carcinogen.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Benzo(a)pyrene

Benzo(a)pyrene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also manmade. Benzo(a)pyrene occurs naturally in coal tar, crude oil, and is formed from incomplete combustion of organic material.

Human data demonstrating a causal relationship linking benzo(a)pyrene to carcinogenicity are lacking. However, multiple animal studies in many species demonstrate benzo(a)pyrene to be carcinogenic following administration by a variety of routes. The mechanism through which benzo(a)pyrene elicits its carcinogenic potential is well understood. Benzo(a)pyrene has produced positive results in numerous genotoxicity assays. Benzo(a)pyrene has been classified by the USEPA as a B2, probable human carcinogen.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Benzo(b)fluoranthene

Benzo(b)fluoranthene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also manmade. Benzo(b)fluoranthene occurs naturally in coal tar, crude oil, and is formed from incomplete combustion of organic material.

Although there are no human data that specifically link exposure to benzo(b)fluoranthene to human cancers, benzo(b)fluoranthene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke. Benzo(b)fluoranthene produced tumors in mice after lung implantation, intraperitoneal, or subcutaneous injection, and skin painting. Benzo(b)fluoranthene has produced positive results in several genotoxicity assays. It has been classified as a B2, probable human carcinogen, by the USEPA.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Benzo(g,h,i)perylene

Benzo(g,h,i)perylene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also man made. They occur naturally in coal tar, crude oil, and are formed from incomplete combustion of organic material.

There are no available data regarding human exposures. There are inadequate animal data from lung implant, skin-painting and subcutaneous injection bioassays. The USEPA has determined that benzo(g,h,i)perylene is not classifiable as to human carcinogenicity, and has assigned it to class D.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Benzo(k)fluoranthene

Benzo(k)fluoranthene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also manmade. Benzo(k)fluoranthene occurs naturally in coal tar, crude oil, and is formed from incomplete combustion of organic material.

Although there are no human data that specifically link exposure to benzo(k)fluoranthene to human cancers, benzo(k)fluoranthene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke. Benzo(k)fluoranthene produced tumors after lung implantation in mice and when administered with a promoting agent in skin-painting studies. Benzo(k)fluoranthene is mutagenic in bacteria. Benzo(k)fluoranthene has been classified by USEPA as a B2, probable human carcinogen.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Bis(2-ethylhexyl)phthalate (DEHP)

DEHP is used industrially as a plasticizer for resins to make plastic materials more flexible, thus it is found in many plastic materials. It is also used in manufacturing organic pump fluids in electrical capacitors.

Human exposure to DEHP has produced eye irritation, nausea, and diarrhea. Most of the toxicity data for DEHP are obtained from animal studies. DEHP targets the liver, causing morphological and biochemical changes, as well as the testes, producing damage to the seminiferous tubules. DEHP has produced developmental and reproductive effects in laboratory animals including spina bifida and reduced fertility. The overall evidence from many studies indicates that DEHP is not mutagenic. DEHP has been shown to cause a dose-related increase in liver tumors in mice and rats. Thus, the USEPA has designated DEHP as a B2, probable human carcinogen.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Calcium

Calcium is a naturally occurring element which exists as an ubiquitous constituent of natural waters and soils. Human activities also contribute calcium ions to natural waters. Calcium or calcium-containing products are used in a wide variety of manufacturing operations and as chemical intermediates. Calcium is an essential nutrient to humans. It plays important roles in blood coagulation, maintenance of muscle tone, and excitability of nervous and muscle tissue. Because of large amounts of storage within bone tissue, calcium is the most abundant ion in the body.

Calcium levels within the body are controlled through the regulation of absorption and excretion dependent on serum calcium levels, Vitamin D, parathyroid hormone, and calcitonin levels. Excess oral intake typically does not result in toxicity since excess calcium will not be absorbed in otherwise normal individuals. Minimal gastrointestinal irritation, accompanied by nausea and vomiting, may result from the presence of large amounts of unabsorbed calcium within the intestines. If abnormally high level of calcium are present within the blood, a condition termed hypercalcemia, lethargy, weakness, anorexia, polyuria, bone pain, paresthesia, confusion, and coma have been reported. No evidence of carcinogenicity in humans or animals exists.

References:

Tortora, J.T. and Grabowski, S.R., 1993. Principles of Anatomy and Physiology, 7th edition. Harper Collins College Publishers, New York, NY. p. 910

Chrysene

Chrysene is one of the polycyclic aromatic hydrocarbons (PAH) compounds which are formed during the combustion of organic material. Although there are no human data that specifically link exposure to chrysene to human cancers, chrysene is a component of mixtures that have been associated with human cancer. These include coal tar, soots, coke oven emissions and cigarette smoke. Chrysene produced chromosomal abnormalities in hamsters and mouse germ cells after gavage exposure, positive responses in bacterial gene mutation assays and transformed mammalian cells exposed in culture. Due to its similarities with benzo(a)pyrene and other carcinogenic PAHs, chrysene has been classified as a B2, probable human carcinogen.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Cobalt

Cobalt is an essential metal as a component of Vitamin B_{12}. It is a relatively rare metal produced primarily as a by-product of other metals, chiefly copper. Cobalt has been used in the manufacture of cobalt salts, permanent magnets, tools, cars, electrical components, and aircraft; in alloys as dental materials; in cutting materials, water-resistant materials, lacquers, varnishes, and paint driers; and in the production of inks, enamels, glazes, glass decolorizer, and catalysts.

Cobalt salts are relatively well absorbed after oral administration. Excretion through urine and feces tends to parallel absorption. Therefore, elevated intakes tend to not cause significant body accumulation. Fat and muscle contain the highest levels followed by the liver, the heart, and hair.

Toxicity following excess therapeutic administration has been reported to include vomiting, diarrhea, increased blood pressure, slowed respirations, and tinnitus progressing to deafness. An epidemiological association between high endemic soil and water cobalt levels and goiter has been reported. Cardiomyopathy has been caused by excessive intake of cobalt in beer. Occupational exposure to airborne cobalt has produced irritation to the eyes and skin. Chronic exposure has resulted in human lung fibrosis in some cases. There is no evidence of carcinogenicity in humans or animals from any naturally occurring route of exposure.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1991. "Toxicological Profile for Cobalt"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, February 1991.

Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds), 1986. Handbook of the Toxicology of Metals. 2nd ed. Vol I, II.: Amsterdam: Elsevier Science Publishers B.V., p. V2 221.

Goyer, R.A., 1991. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Eds. C.D. Klaassen, M.O. Amdur and J. Doull. Macmillan Publishing Co. N.Y.

Dibenzofuran

Dibenzofuran is an unsubstituted organic compound that contains two benzene rings fused to a central furan ring. Dibenzofuran is a manmade chemical which may be introduced into the environment as a contaminant of commonly used pesticides (e.g., 2,4,5-T). Extensive toxicological information exists on the chlorinated species of dibenzofuran (chlorodibenzofurans), but minimal information is available concerning the unsubstituted parent molecule. Dibenzofuran, with no chlorine substituents, is believed to have minimal toxicity compared to the chlorinated forms due to its lack of solubility and biological activity. A toxicity equivalency factor for dibenzofuran has been set by USEPA equal to zero, relative to the chlorinated isomers. Dibenzofuran is not mutagenic, with or without metabolic activation, in several in vitro mutagenicity tests. There are no data on the possible carcinogenicity of dibenzofuran alone in animals or humans.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1993. "Toxicological Profile for Chlorodibenzofurans"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, February 1993.

Integrated Risk Information System (IRIS), 1993. United States Environmental Protection Agency.

Dichlorobenzene

Dichlorobenzene is a semivolatile organic compound which exists in three isomeric forms; 1,2- , 1,3- and 1,4-dichlorobenzene. The chemical and physical properties of the three forms vary extensively with 1,2-dichlorobenzene existing as a pale yellow liquid to 1,4-dichlorobenzene which exists as a white solid with a mothball odor. The solid sublimates directly into a vapor form. Dichlorobenzene does not exist naturally, but is produced as a chemical intermediate, a household and agricultural deodorizer, insecticide, and a component of resins. It may be present in air, water, soil, and foods such as pork, chicken, fish, eggs, and milk.

Dichlorobenzene may be absorbed following any route of exposure. Inhalation appears to be the most important human exposure pathway even though oral

exposures are absorbed more efficiently. The predominant route of excretion is through urine, however, elimination may also occur through feces.

Following exposure in air, dichlorobenzene causes irritation to eyes, mucous membranes and the upper respiratory tract. After systemic absorption via any route of exposure, hematological effects, including hemolytic anemia and methemoglobinemia have been reported. Other systemic effects include mild CNS depression with the liver and kidney as additional target organs. Limited animal studies raise the possibility that dichlorobenzene may adversely affect reproductive/developmental success. Results of mutagenicity tests have been generally negative except for systems examining DNA replication in liver and kidney in vivo following oral exposure to 1,4-dichlorobenzene. Carcinogenicity studies in laboratory animals have demonstrated an increase in liver tumors following chronic oral dosing. 1,4-Dichlorobenzene has been classified into Category C as a suspected human carcinogen by USEPA.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1992. "Toxicological Profile for 1,4-Dichlorobenzene"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, February 1992.

Mycroft, F.J., Jones, J.R., and Olson, K.R., 1990. Environmental and Occupational Toxicology. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. pp. 395-6.

1,2-Dichloroethene (cis & trans)

1,2-Dichloroethene is a volatile organic compound which exists as cis- and trans-isomers. The commercially used material is usually a mixture of the two isomers. In the past, it was used as a general inhalation anesthetic. It is currently used as an extraction solvent or as a component of dyes, perfume oils, waxes, resins, and plastics. It is also used as an intermediate in the synthesis of polymers.

1,2-Dichloroethene is absorbed by all routes of administration. Distribution is rapid and, due to its lipophilic nature, occurs to all organ systems. It is

extensively metabolized to dichloroacetaldehyde and chloroacetic acids which are excreted primarily through urine.

Dermal contact to 1,2-dichloroethene may result in defatting of the skin and dermatitis. Exposure to airborne 1,2-dichloroethene causes irritation to eyes, mucous membranes and the upper respiratory tract. Systemically, the trans-isomer is believed to be more toxic than the cis-isomer. However, both have been reported to produce central nervous system depression and toxicity to liver and lungs. No data on the reproductive toxicity of 1,2-dichloroethene exists. Both isomers have tested negative for mutagenicity in vitro tests. Cancer effects have not been studied in humans or animals.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1990. "Toxicological Profile for 1,2-Dichloroethene"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, February 1990.

Mycroft, F.J., Jones, J.R., and Olson, K.R. 1990. Environmental and Occupational Toxicology. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. p. 397.

1,2-Dichloropropane

1,2-Dichloropropane is a volatile organic compound which exists as a colorless liquid with a mild fruity odor. Currently, it is used only in research and in industrial applications as a chemical intermediate and solvent. Previously, it was used agriculturally as a soil fumigant, and in paint strippers, varnishes and finish removers. Releases to the environment are as a result of human activities and result in air, soil and groundwater contamination.

Absorption occurs following exposure by any route. However, absorption is most efficient following oral exposures. Due to its lipid solubility, distribution occurs rapidly to all organ systems. Excretion occurs via expired air, urine and feces.

Inhalation exposures may result in central nervous system depression, eye irritation, chest discomfort, dyspnea, cough and pulmonary edema. Additionally,

nausea, vomiting and effects on the liver, kidney and hematological systems have been noted. Liver and kidney effects are characterized as primarily fatty degeneration. Oral exposures produce similar toxic symptoms. Mutagenicity tests in bacteria, mammalian and non-mammalian cells, and Drosophila predict that 1,2-dichloropropane may pose a genotoxic threat to humans. Carcinogenicity studies in animals have yielded equivocal data resulting in no USEPA classification as to carcinogenicity.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1989. "Toxicological Profile for 1,2-Dichloropropane"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, April 1989.

Fluoranthene

Fluoranthene is one of the polycyclic aromatic hydrocarbons (PAH) compounds which are formed during the combustion of organic material. Although there are no human data that specifically link exposure to chrysene to human cancers, fluoranthene is a component of mixtures that have been associated with human cancer. It is a constituent of coal tar and petroleum-derived asphalt. No data regarding human exposure are available, and animal data suggest that fluoranthene is not carcinogenic. Fluoranthene has been shown to be mutagenic when metabolically activated. Fluoranthene has been classified by USEPA as D, not classifiable as to human carcinogenicity.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Indeno(1,2,3-cd)pyrene

Indeno(1,2,3-c,d)pyrene is one of the polycyclic aromatic hydrocarbons (PAH) compounds which are formed during the combustion of organic material and is a

component of cigarette smoke and smoke stack emissions. No carcinogenicity data specifically for indeno(1,2,3-c,d)pyrene are available in humans, however, toxic effects are attributable to mixtures of PAHs. Animal studies indicate that indeno(1,2,3-c,d)pyrene can induce skin tumors in mice, and may have some immunosuppressive effects. In mammalian cell cultures, indeno(1,2,3-c,d)pyrene was found to be genotoxic. It has been classified by the USEPA as a B2 carcinogen.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Iron

Iron is a metal which is required for a variety of physiological functions such as heme biosynthesis, oxidative phosphorylation and mixed-function oxidase-mediated metabolic reactions. Only divalent forms of iron are absorbed. As absorption occurs, divalent iron is biochemically converted to trivalent iron, the biologically active form. Under normal conditions, absorbed dietary iron is complexed to hemoglobin and transported to the liver for storage until needed for physiological reactions. The balance of iron is regulated only by the amount of dietary intake and the degree of intestinal absorption. Intestinal absorption tends to be low (2 - 15%) except during periods of increased iron need when absorption efficiency increases dramatically.

Acute iron toxicity has been well characterized following the accidental ingestion of iron-containing preparations by children. Shortly after ingestion, the corrosive effects of iron cause vomiting and diarrhea, often bloody. Later signs include shock, metabolic acidosis, seizures, liver and/or kidney failure, coma, and death. Chronic iron overload manifests as disturbances in liver function, diabetes mellitus, and endocrine and cardiovascular effects. Inhalation of iron containing dust or fumes in occupational settings may result in deposition of iron particles in the lungs leading to interstitial fibrosis. Autopsies of hematite miners noted an increase in lung cancer. However, the etiology of the lung cancer may be related to factors other than iron exposure such as cigarette, silica or PAH exposures.

References:

Aisen, P., Cohen, G. and Kang, J.O., 1990. Iron Toxicosis. Int. Rev. Exp. Pathol. 31:1-46.

Goyer, R.A., 1991. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Eds. C.D. Klaassen, M.O. Amdur and J. Doull. Macmillan Publishing Co. N.Y.

Magnesium

Magnesium is the eighth most common element in the earth's crust. It is a divalent cation required for a variety of enzymatic reactions involving protein synthesis and carbohydrate metabolism. It is also an essential ion for proper neuromuscular function. Magnesium is used in lightweight alloys, as an electrical conductive material, and for incendiary devices such as flares. Human exposure occurs largely through the ingestion of drinking water, foods containing high levels of magnesium, such as nuts, cereals, seafood and meats, and through the use of magnesium-containing antacids and cathartics.

Magnesium is moderately absorbed (50%) from the gastrointestinal tract. Once absorbed, excess magnesium is rapidly excreted through urine. The majority of body magnesium is localized in bone and muscle.

Intoxication following oral administration of magnesium is rare, occurring largely in patients with pre-existing renal insufficiency. Large amounts of orally administered magnesium cause diarrhea that can result in major fluid and electrolyte losses. Following absorption, lethargy, weakness, and central nervous system depression are noted which may progress to hypotension, bradycardia, conduction defects, and respiratory arrest. Inhaled magnesium in industrial settings can cause metal fume fever, conjunctivitis, and coughing. No evidence of carcinogenicity in humans or animals exists.

References:

Buchanan, J.F., 1990. Magnesium. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. 4pp. 194.

Goyer, R.A., 1991. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Eds. C.D. Klaassen, M.O. Amdur and J. Doull. Macmillan Publishing Co. N.Y.

Speich, M. and Bousquet, B., 1991. Magnesium: Recent Data on Metabolism, Exploration, Pathology and Therapeutics. Magnesium-Bull. 13:116-121.

Methyl Butyl Ketone (2-Hexanone)

Methyl butyl ketone (2-hexanone) is a waste product of wood pulping, coal gasification and oil shale operations. It was formerly used in paint and paint thinner. MBK is an irritant of mucous membranes and eyes. It is a narcotic and in high concentrations causes CNS effects including weakness, numbness and tingling in the skin of the hands and feet. It is absorbed by the skin. It has been shown to cause liver and kidney effects in laboratory rats. There is no USEPA evidence to demonstrate carcinogenicity.

References:

Agency for Toxic Substances and Disease Registry (ATSDR), 1990. "Toxicological Profiles for 2-Hexanone". Agency for Toxic Substances and Disease Registry, US Public Health Services, October 1990.

Health Effects Summary Tables (HEAST), United States Environmental Protection Agency, November, 1992.

Methyl Ethyl Ketone (2-Butanone)

Methyl ethyl ketone (2-Butanone) has been used as a solvent for coatings, adhesives, and cements; and in the lacquer and varnish industries. Human exposure to MEK has produced irritation to mucous membranes and conjunctiva; prolonged exposure to high concentrations has caused CNS depression. MEK has a low toxicity following acute and chronic human exposures. Exposure studies in animals indicate the liver and the kidney as target tissues of MEK. MEK can potentiate the neurotoxicity of other solvents such as n-hexane, methyl butyl ketone, and ethyl butyl ketone. Mild but significant developmental effects have

been produced in rats by exposure to MEK. MEK has been classified by USEPA as D, not classifiable as to human carcinogenicity. Results of in vitro tests for genotoxicity have proved negative.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Phenanthrene

Phenanthrene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also man made. Phenanthrene occurs naturally in coal tar, crude oil, and is formed from incomplete combustion of organic material.

Phenanthrene has been shown to be a skin photosensitizer in humans. Intraperitoneally injection in rats produced liver effects. Although limited evidence exists that phenanthrene is a mutagen, the majority of tests have proved negative. Equivocal evidence exists for cancer after dermal application of phenanthrene in rats. Ingestion of 200 mg of phenanthrene produced no tumors in rats after two months.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Potassium

Potassium is a naturally occurring element which exists as an ubiquitous constituent of natural waters and soils. Human activities also contribute potassium ions to natural waters. Potassium or potassium-containing products are

used in a wide variety of manufacturing operations and as chemical intermediates. Potassium is an essential nutrient to humans.

Tissue and blood potassium levels are dependent upon potassium intake and excretion. Little information exists concerning the direct toxicity of excessive potassium intake. However, the presence of elevated serum potassium levels (hyperkalemia) in humans is common and well characterized. Elevated serum potassium levels produce muscular weakness and interfere with normal cardiac electrical function. Ventricular fibrillation and cardiac arrest may result. There is no evidence for carcinogenicity by potassium.

References:

Olson, K.R., 1990. Emergency Evaluation and Treatment. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. pp. 32.

Pyrene

Pyrene is a member of the polycyclic aromatic hydrocarbons (PAH) class of compounds which contain two or more aromatic rings. PAHs are ubiquitous in nature and are also man made. Pyrene occurs naturally in coal tar, crude oil, and is formed from incomplete combustion of organic material.

Pyrene is reported to be a skin irritant to humans. Rats dosed with pyrene showed blood chemistry changes, as well as liver and kidney damage. Pyrene tests positive for mutagenicity *in vitro* mammalian systems. Pyrene has been classified as D, not classifiable as to human carcinogenicity.

References:

MADEP, 1992. "Risk Assessment Shortform Residential Exposure Scenario, Version 1.6"; Policy #WSC/ORS-142-92; Office of Research and Standards and the Bureau of Waste Site Cleanup, Boston, MA; September 1992.

Selenium

Selenium is a trace metal considered an essential element in the human diet, with multiple roles in metabolic chemistry. It exists as multiple chemical forms including selenate (Se^{+6}), selenite (Se^{+4}), elemental selenium (Se^{+0}) and selenide (Se^{-2}). Selenium is used in the electronics industry in photoelectric cells and solar batteries; in glass, rubber, steel and ceramic manufacturing; and in some paints, varnishes, fungicides, and insecticides. Food sources of selenium include seafood, especially shrimp, meat, milk products, and grains.

Absorption and toxicity of selenium are largely dependent on the chemical form. Selenates are relatively soluble and well absorbed in contrast to the other chemical species which are virtually insoluble. Once absorbed, selenates widely distribute within the body. Excretion occurs through urine and feces.

Inhalation of selenium gases may cause burning eyes and throat, coughing, wheezing, chemical pneumonitis, and pulmonary edema. Acute ingestion may cause vomiting, hypersalivation, a garlic-like odor of the breath, and central nervous system effects including nervousness and drowsiness. Hypotension, coma and convulsions have also been reported. Chronic intoxication is associated with impairment of vision, peripheral weakness, discoloration and loss of hair and nails, polyneuritis, fatigue, garlicky breath, liver damage, dermatitis, nausea and vomiting. Animal studies suggest that chronic excessive selenium exposure is embryotoxic and teratogenic, causes hepatic cirrhosis and may be carcinogenic. Human epidemiological studies suggest an apparent protective effect of elevated dietary selenium against some carcinogenic agents.

References:

Tweig, M. and Olson, K.R., 1990. Selenium. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. pps. 267-8.

Goyer, R.A., 1991. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Eds. C.D. Klaassen, M.O. Amdur and J. Doull. Macmillan Publishing Co. N.Y.

Sodium

Sodium is an ubiquitous constituent of natural waters. Human activities also contribute sodium ions to natural waters. Sodium has been used in the manufacture of other sodium compounds, tetraethyl lead, in organic synthesis, in alloys, and as a chemical intermediate. Sodium is a naturally occurring element and an essential nutrient to humans.

Sodium is toxic only at very high concentrations. Chronic ingestion of elevated sodium levels may result in or aggravate hypertension in humans. Hypertension has also been demonstrated in animals chronically exposed to sodium in their diets. Sodium can be an eye irritant. There is no evidence for carcinogenicity by sodium.

References:

National Academy of Sciences, 1977. "Drinking Water and Health"; Safe Drinking Water Committee, Washington, D.C.

Thallium

Thallium is a naturally occurring soft metal that is a minor constituent in a variety of ores and is obtained as a by-product of the refining of iron, cadmium, and zinc. It is used as a catalyst, in certain alloys, jewelry, thermometers, semiconductors, dyes and pigments, and optical lenses. It has been used medically as a depilatory agent. Additionally, it is used as a rodenticide and insecticide.

Thallium is efficiently absorbed from the gastrointestinal tract. Excretion occurs primarily through urine and feces. Following absorption, distribution occurs to kidney tissue to a large extent, with lesser distribution to thyroid, intestines, testes, pancreas, skin, bone, and spleen.

Thallium is one of the more toxic metals. Acute toxicity results in gastrointestinal irritation, shock, ascending paralysis, seizures, and psychic disturbances. Signs of subacute or chronic thallium poisoning include hair loss, nail dystrophy, cataracts, peripheral muscular weakness and atrophy, chorea, peripheral neuropathy, and kidney damage. Loss of vision have been related to industrial thallium exposures. No information is available which addresses the carcinogenic potential of thallium.

References:

Goyer, R.A., 1991. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd edition. Eds. C.D. Klaassen, M.O. Amdur and J. Doull. Macmillan Publishing Co. N.Y.

Tweig, M., 1990. Thallium. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. pp. 276-7.

Trichlorofluoromethane

Trichlorofluoromethane, also called Freon 11, belongs to a group of structurally related volatile chemicals called chlorofluorocarbons (CFCs). Little specific information is available for trichlorofluoromethane. However, information available for structurally similar CFCs is probably applicable to trichlorofluoromethane. As a group, CFCs are used as aerosol propellants, refrigerants, foaming agents in the manufacture of styrofoam, and as cleaners of electrical components. CFCs are reported to be responsible for the depletion of the ozone layer due to their long atmospheric half-life and subsequent dechlorination which occurs within the stratosphere.

CFCs have been reported to possess a relatively low order of human toxicity. Even though relatively inert, they have been demonstrated to produce health effects following inhalation, oral and dermal contact. Following contact, CFCs are rapidly absorbed into the blood stream and are distributed throughout the body. High level exposure in humans produces primarily central and peripheral nervous system effects such as impaired performance, dizziness, tingling, tremors, EKG and speech disturbances, unconsciousness and cardiac arrhythmias. CFCs also have direct irritant effects upon contact with skin, eyes and mucous membranes. Chronic exposures in laboratory animals have been reported to produce liver pathology. No information is available concerning the mutagenicity or carcinogenicity of trichlorofluoromethane.

References:

Azar, A., 1972. Experimental Human Exposures to Fluorocarbon 12 (Dichlorodifluoromethane). Am. Ind. Hyg. Assoc. J. 33: 207-213.

Imbus, H.R. and Adkins, C., 1972. Physical Examination of Workers Exposed to Trichlorotrifluoroethane. Arch. Environ. Health 24: 257-261.

Mycroft, F.J., Jones, J.R., and Olson, K.R., 1990. Environmental and Occupational Toxicology. In: Poisoning and Drug Overdose. Ed. K.R. Olson. Appleton & Lange, CT. p. 470.